January 1996
NSRP 0468

SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Short Course on Implementing Advanced Technology

Course Notes

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

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DISCLAIMER

P 3468

SHORT COURSE ON

IMPLEMENTING ADVANCED TECHNOLOGY

COURSE NOTES

[VERSION 1/96]

A TRAINING INITIATIVE
OF
THE UNIVERSITY OF MICHIGAN
O R
THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

NATIONAL SHIPBUILDING RESEARCH PROGRAM

TWO DAY SHORT COURSE
ON
IMPLEMENTING ADVANCED TECHNOLOGY

COURSE BOOK CONTENTS

AGENDA - THURSDAY, MARCH 21,1996

8-8.15AM	INTRODUCTIONS	
8.45-9.15AM	SETTING THE STAGE - WORLD SHIPBUILDING	
9.15-9.45AM		SHIPBUILDING COMPETITIVENESS
9.45-10.00 AM	EXERCISE - CGT	
10.00-10.15 AM	BREAK	
10.15- 10.30AM		U.S. SHIPBUILDING
10.30-11.00AM		TECHNOLOGY TRANSFER.
11.00-11.30PM		WHAT IS WORLD CLASS
11.30 AM - 12.30PM	LUNCH	
12.30-1.00 PM	EXERCISE - U.S. VERSUS FOREIGN COST BREAKDOWN	
1.00-1.30 PM	THE CANDY STORE -	TOTAL QUALITY MANAGEMENT
1.30-2000 PM		SEAMLESS ENTERPRISES
2000-2.15 PM	BREAK	
2.15-2.45 PM		RE-ENGINEERING
2.45-3.00 PM		BUSINESS PROCESS RE-ENGINEERING
3.00-3.30 PM		VIRTUAL ORGANIZATIONS
3.30- 4.00PM	EXERCISE	

AGENDA - FRIDAY, MARCH 22,1996

8-8.15AM	THURSDAY REVIEW	
8.15-9.00AM	MANAGING CHANGE -	UNDERSTANDING CHANGE
		BARRIERS TO CHANGE
		HOW TO INCREASE YOUR CHANCE OF SUCCESS
9.00-9.30 AM	EXERCISE	
9.30-10.00 AM	THE TOOLS -	UNDERSTANDING VARIATION
10.00-10.15 AM	BREAK	
10.15- 10.45 AM		ACTIVITY BASED COSTING
10.45-11.30 AM		CONCURRENT ENGINEERING - IPPD
11.30 AM - 12.30PM	LUNCH	
12.30-1.00 PM	EXERCISE - CE READINESS	
12,30-2.15 PM	TEAMS AND TEAMWORK	
2.15-2.45 PM	EXERCISE	
2.45-3.00 PM	BREAK	
3.00-3.45 PM	STRATEGY FOR IMPLEMENTING AT IN U.S. SHIPBUILDING	
3.45-4.00 PM	WRAP-UP	

NATIONAL SHIPBUILDING RESEARCH PROGRAM

SETTING

THE

STAGE

IMPLEMENTING ADVANCED TECHNOLOGY

WORLD SHIPBUILDING

- PRICES ARE STILL LOWER THAT COST IN MOST COUNTRIES
- ORDERS IN 1995 ARE LESS THAN ORDERS IN 1994
- TOTAL DEADWEIGHT ON ORDER IS ABOUT 25 MILLION TDWT
- WORLD SHIPBUILDING CAPACITY IS OVER 30 MILLION TDWT
- TOTAL NUMBER OF SHIPS ON OVER IS ABOUT 700"
- KOREA HAS HAD THE MOST GAIN IN TERMS OF TDWT
- KOREA HAS TAKEN LEAD FROM JAPAN IN TERMS OF TDWT BUT JAPAN STILL HAS SIGNIFICANT LEAD IN TERMS OF NUMBER OF SHIPS

WORLD SHIPBUILDING (Continued)

- EUROPE HAS LOST 300A SINCE 1991
- THERE IS FIERCE COMPETITION IN THE CONTAINER SHIP MARKET FOR ALL SIZES. JAPAN HAS RECENTLY BOOKED 16 LARGE CONTAINER SHIPS. SMALLER SHIPS ARE SHARED BY POLAND AND GERMANY
- BULK CARRIER MARKET STILL APPEARS STRONG
- INDONESIAN SHIPBUILDERS ARE CAPTURING SOME ORDERS, INCLUDING REEFERS, A TRADITIONAL EUROPEAN MARKET

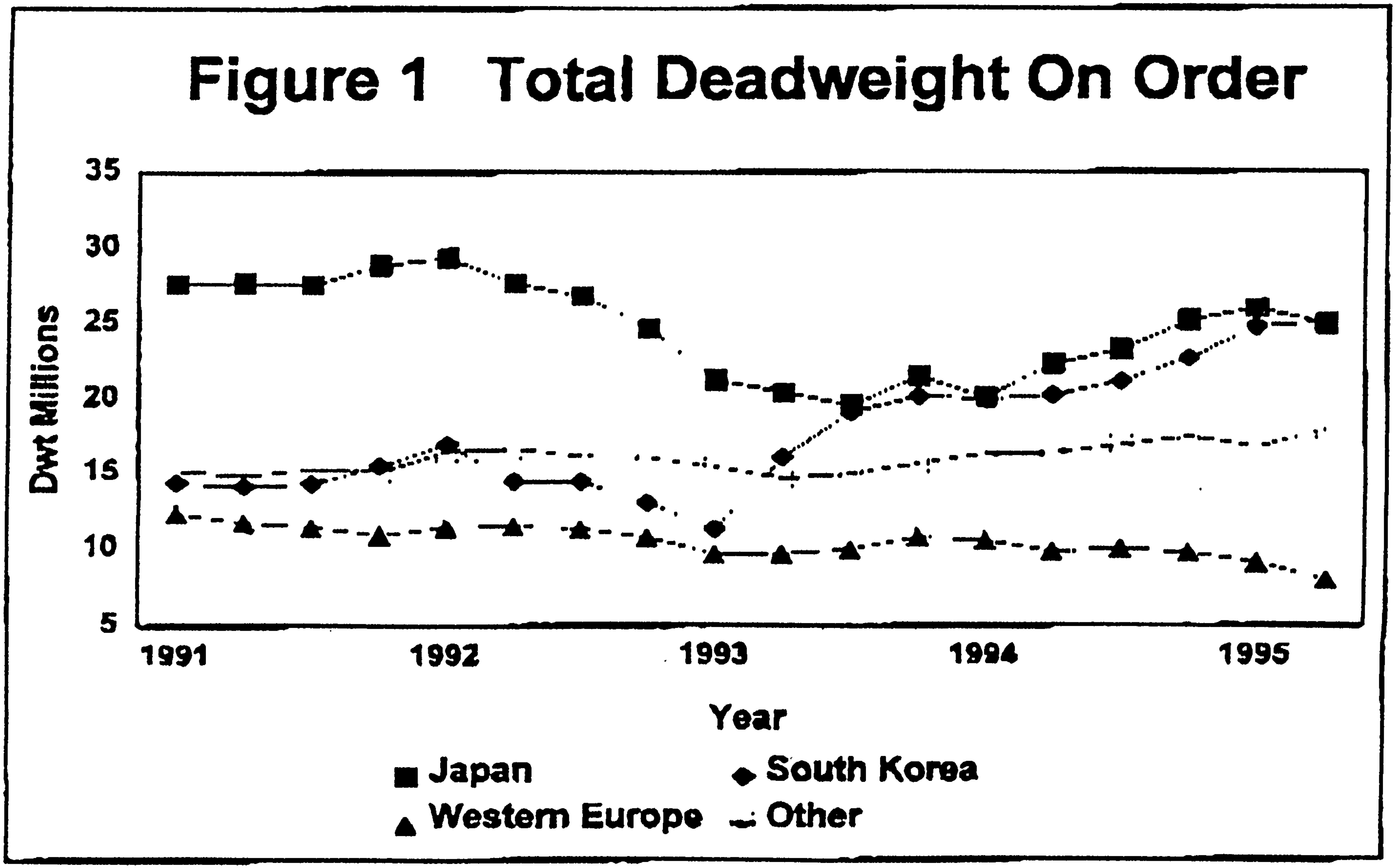

Figure 1 Total Deadweight On Order
35
30
25
20
15
10
5
Dwt Millions
1991
1992
1993
1994
1995
Year
Japan
South Korea
Western Europe
Other

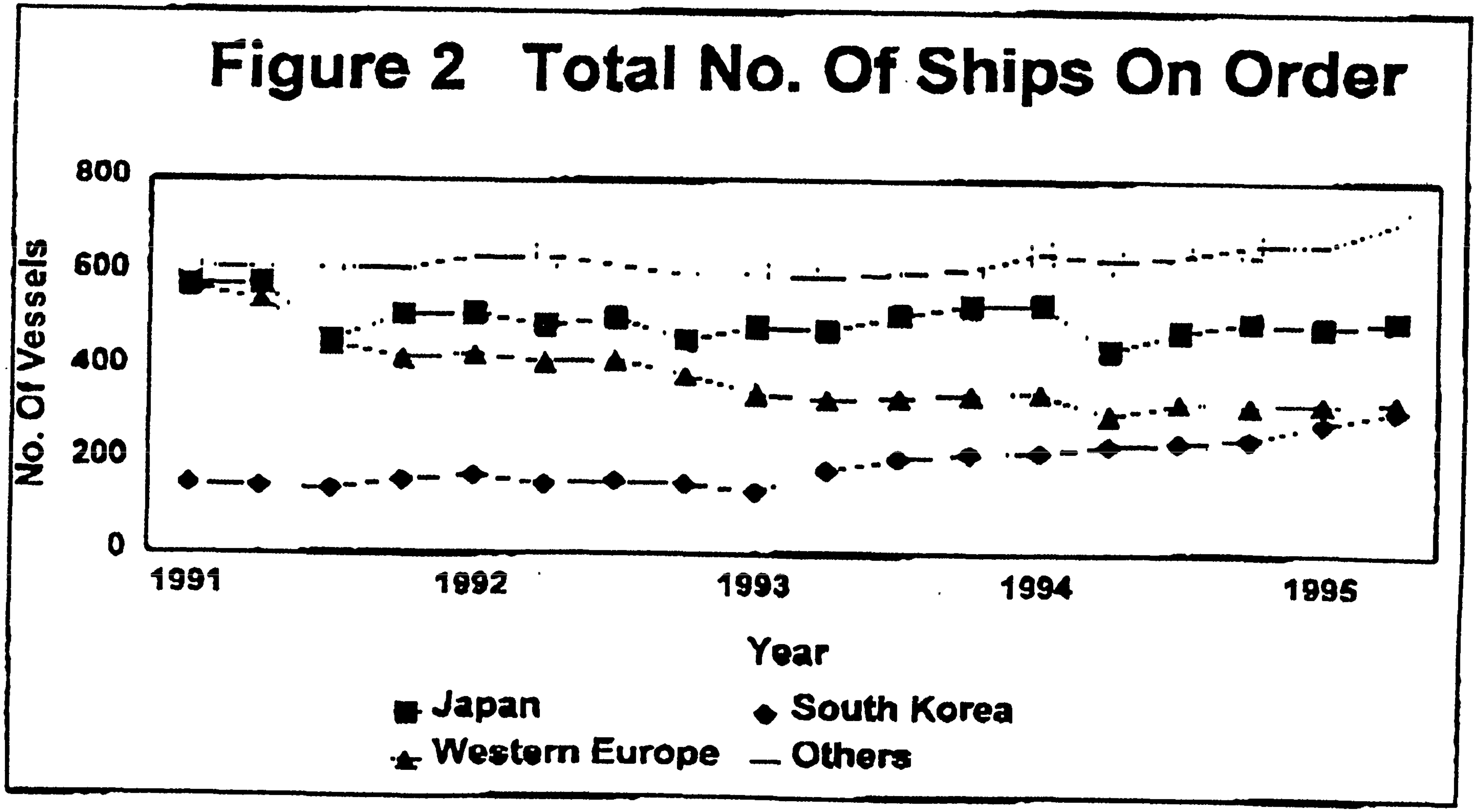
Figure 2 Total No. Of Ships On Order
800
600
400
200
0
No. Of Vessels
1991
1992
1993
1994
1995
Year
Japan
South Korea
Western Europe
Others

SHIPBUILDING MARKET SHARE

[A] SHARE BY DWT ON ORDER

SHIPBUILDING BLOCK	MARKET SHARE 1991	1995
JAPAN	40%	33%
SOUTH KOREA	21%	33%
WESTERN EUROPE	18%	11%
OTHERS	22%	24%

[B] SHARE BY NUMBER OF SHIPS ON ORDER

	1991	1995
JAPAN	30%	27%
SOUTH KOREA	8%	17%
WESTERN EUROPE	30%	18%
OTHERS	32%	38%

SOURCE: A&P APPLEDORE USING DATA FROM FAIRPLAY SHIP ON ORDER

U.S. SHIPBUILDING

#

- EARLY SUCCESS IN OBTAINING COMMERCIAL ORDERS HAS BOGGED DOWN IN TITLE XI APPROVAL WHICH IS TAKING A LONG TIME DUE TO AMOUNT OF APPLICATIONS
- AT $38 MILLION FOR EACH OF THE FIRST FOUR DOUBLE EAGLE TANKERS, IT IS UNLIKELY NEWPORT NEWS WILL MAKE A PROFIT. HOWEVER, IT WILL HELP TO SUSTAIN THEIR MANNING LEVEL AND EVENTUALLY, WITH FURTHER ORDERS, THEY SHOULD BE ABLE TO MAKE A PROFIT
- AT $45 MILLION FOR EACH OF THEIR FOUR PRODUCT TANKER FOREBODIES, AVONDALE’S HOPES TORE-ENTER THE COMMERCIAL MARKET PROFITABLY
- AVONDALE’S RUSSIAN TANKER, AND BENDER’S REEFER SHIP PROJECTS ALL APPEAR DEAD
- OTHER U.S. SHIPBUILDERS ARE STILL IN NEGOTIATION WITH POTENTIAL FOREIGN AND U.S. CUSTOMERS

SP-4 COMPARATIVE GLOBAL SHIPBUILDING TECHNOLOGY STUDIES

COMPETITIVENESS VERSUS TECHNOLOGY---------

COMPETITIVENESS DEPENDS ON A NUMBER OF FACTORS INCLUDING PRODUCTIVITY WHICH IS ONLY PARTLY INFLUENCED BY TECHNOLOGY.

THE FACTORS ARE:

- PRODUCTIVITY
- MATERIAL COST
- DELIVERY SCHEDULE
- LABOR RATES
- NATIONAL SHIPBUILDING POLICY
- MARINE INDUSTRY INFRASTRUCTURE
- FINANCING
- SUBSIDIES

SHIPBUILDER INFLUENCED

COUNTRY INFLUENCED

SP-4 COMAPARATIVE GLOBAL SHIPBUILDING TECHNOLOGY STUDIES

TECHNOLOGY DEVELOPMENT RESEARCH-APPROACH

EUROPE	SHIPBUILDERS RESEARCH ASSOCIATION SHIPYARD/UNIVERSITY SHIPYARD ALLIANCES
JAPAN	NATIONAL PROGRAMS SHIPBUILDERS RESEARCH ASSOCIATION SHIPYARD ALLIANCES
US*	NATIONAL SHIPBUILDING RESEARCH PROGRAM INDIVIDUAL SHIPYARDS

SHIPYARD COMPETITIVENESS

THERE IS NO UNIVERSALLY ACCEPTED DEFINITION OF COMPETITIVENESS. KPMG PEAT MARWICK, IN THEIR STUDY OF THE COMPETITIVENESS OF EEC SHIPYARDS, DEFINE IT AS "THE ABILITY TO WIN AND EXECUTE SHIPBUILDING ORDERS IN OPEN COMPET1TION AND STAY IN BUSINESS." I WOULD ADD

PROFITABLY.

A MEASURE THAT HAS BEEN ACCEPTED BY OECD TO COMPARE SHIPBUILDING PRODUCTIVITY IS MANHOURS/COMPENSATED GROSS TONNAGE (CGT).. THIS CAN BE MADE INTO A QUASI COMPETITIVENESS MEASURE BY MULTIPLYING THE MANHOURS BY THE COUNTRY SHIPYARD LABOR IU4TE IN U.S. DOLLARS

THIS MEASURE FOR A SHIPYARD CAN BE PLOTTED ON CONSTANT COST CURVES AND COMPARED TO OTHER'WORLD SHIPBUILDERS

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SHIPYARD COMPETITIVENESS

COMPENSATED GROSS TONNAGE

COMPARING SHIPS ON THE BASIS OF THEIR GROSS TONNAGES IS NOT USEFUL BECAUSE THE WORK CONTENT OF DIFFERENT SHIP TYPES AND SIZES IS NOT TAKEN INTO ACCOUNT. TO OVERCOME THIS THE CONCEPT OF COMPENSATED GROSS TONNAGE WAS DEVELOPED. THAT IS THE GROSS TONNAGE FOR A SHIP WOULD BE COMPENSATED TO TAKE ACCOUNT OF THESE IMPORTANT DIFFERENCES. A COMPLETE SET OF COMPENSATION FACTORS HAS BEEN IN DEVELOPEMENT SINCE 1967 AND ACCEPTED BY THE OECD 1984.

UNFORTUNATELY NO COEFFICIENTS HAVE BEEN PUBLISHED FOR WARSHIPS. THIS MAKES IT DIFFICULT, BUT NOT IMPOSSIBLE FOR U.S. SHIPYARDS TO USE THE APPROACH TO COMPARE THEIR CURRENT PERFORMANCE WITH MILITARY SHIPS TO THE WORLD COMMERCIAL SHIPBUILDING MARKET

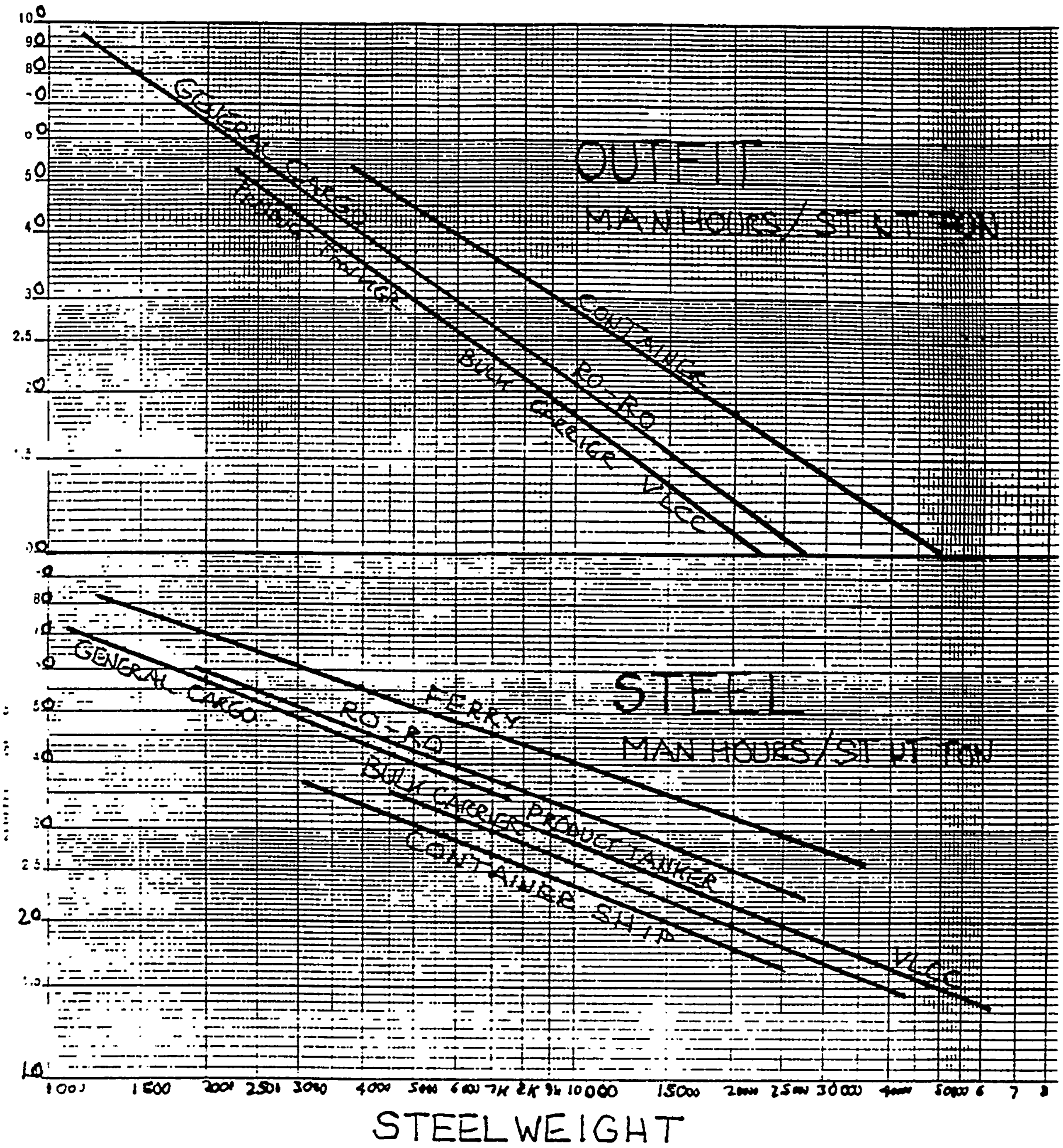
OUTFIT
MAN HOURS/ST WT TON
GENERAL CARGO
CONTAINER
RO-RO
BULK CARRIER
VLCC
STEEL
MAN HOURS/ST WT TON
FERRY
GENERAL CARGO
RO-RO
BULK CARRIER
PRODUCT TANKER
CONTAINER SHIP
VLCC
STEELWEIGHT

FIGURE 4

TABLE I
PRODUCTION MANHOURS

SHIP TYPE	CGT	PRODUCTION MANHOURS EUROPE	PRODUCTION MANHOURS JAPAN
VLCC	37,500	1,185,000	1,030,000
Product Tanker	21,000	475,000	395,000
Bulk Carrier	31,200	643,000	465,000
Container Ship 4,400 TFEU	35,000	765,000	
Container Ship 1,880 TFEU	19,500	434,000	
Ferry	29,000	1,250,000	

TABLE II
CONSTRUCTION TIME IN MONTHS(Keel Laying to Delivery)

SHIP TYPE	EUROPE	DENMARK	JAPAN	USA
VLCC	17	5	9	
Product Tanker	13		8	20
Bulk Carrier	14		8	
Container Ship 4,400 TFEU	17	8	9	
Container Ship 1,880 TFEU	12	7		24
Ferry	13			

TABLE III
DESIGN MANHOURS

SHIP TYPE	DESIGN MANHOURS (Europe)
VLCC	75,500 Single Hull 102,00 Double Hull
Product Tanker	36,000
Bulk Carrier	48,000
Container Ship 4,400 TFEU	72,500
Container Ship 1,880 TFEU	42,500
Ferry	226,000

GROSS TONNAGE AND COMPENSATED GROSS TONNAGE (CGT) COEFFICIENTS

Gross Tonnage is the base measurement of Admeasurement. Admeasurement has a long history starting with the British in 1066, to measure the number of wine casks, or TUNS, that a commercial ship could carry. Over the years it developed to the stage in 1854 where it basically measured the volume of a ship's hull above the floors and inside of the flames, added the volume of the superstructure and divided the total volume by 100, the number of cubic feet in a TUN of wine.

Over the years many techniques were developed to minimize the gross tonnage of a ship, such as "deep floors" and "open spaces". International Tonnage Conventions were held to attempt to reduce differences between the various national systems, but they were not too effective as some large shipping countries did not attend. For example the U.S. did not attend a conference in Paris which limited floor height and made water ballest a deduction from the Gross Tonnage to derive the Net Tonnage. The U.S. has no floor height limitation and by an error made water ballast an exemption from the Gross Tonnage. This means that U.S. Gross Tonnages are usually significantly less than that of other countries.

To eliminate national Gross Tonnage differences IMO held a conference in 1970 and approved anew "International Gross Tonnage measurement system. A major aim was to simplify the calculations and eliminate all of the tonnage reduction techniques and differences between countries. Sufficient signatories were received by 1984 and the Tonnage Convention came into force. For a limited time, individual countries can continue to use their own system for domestic flag non-international ships.

The International Gross Tonnage is simply the molded volume, in cubic meters, of the enclosed spaces in the hull and deckhouse of a ship multiplied by a coefficient. The coefficient is to convert volume to admeasurement tons (.35), and to keep the new Gross Tonnage as close to the existing Gross Registered Tonnage as possible. The coefficient ranges from 0.22 for a small boat of 20 cubic meters volume to 0.32 for a veV large ship with 1 million cubic meters volume. Most hydrostatic programs used today will give you this volume if the hull and deckhouse are completely defined into the computer model as is normally done for the stability calculations.

While most military ships do not have national admeasurement applied, they often have Suez and Panama Admeasurement prepared. These tonnages are based on modified Moorsom System of admeasurement and have developed many inequities because of different interpretations of international conventions by national governments. However, even though it is very simple to calculate, most military ships do not calculate this new Gross Tonnage (GT).

In order to attempt to develop a productivity measure for U.S. shipyards which could be used to determine competitiveness, Gross Tonnage is required. Estimates of Gross Tonnage were made for a number of recent U.S. and British military ships and are given in .

SEE MILITARY GT

PRODUCTIVITY MEASURES

SHIP TYPE	MH/ST. WT. TON	MH/CGT
VLCC	16.0	31.6
SUEZMAX	26.2	30.4
PRODUCT CARRIER	30.9	22.6
CHEMICAL CARRIER	49.8	36.9
BULK CARRIER	19.6	20.6
CONTAINER CARRIER 4,400	18.6	22.0
CONTAINER CARRIER 1,880	26.8	22.3
REEFER	40.7	34.6
FERRY	46.1	43.3
GENERAL CARGO	57.9	16.2
OCEAN TUG	99.5	30.5

cluded from enclosed spaces is limited to the area of the opening (Fig. 9 in Appendix 1).

(e) A recess in the boundary bulkhead of an erection which is exposed to the weather and the opening of which extends from deck to deck without means of closing, provided that the interior width is not greater than the width at the entrance and its extension into the erection is not greater than twice the width of its entrance (Fig. 10 in Appendix 1).

(6) *Passenger*

A passenger is every person other than:

(a) The master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship.

(b) A child under one year of age.

(7) *Cargo Spaces*

Cargo spaces to be included in the computation of net tonnage are enclosed spaces appropriated for the transport of cargo which is to be discharged from the ship, provided that such spaces have been included in the computation of gross tonnage. Such cargo spaces shall be certified by permanent marking with the letters CC (cargo compartment) to be so positioned that they are readily visible and not to be less than 100 millimeters (4 inches) in height.

(8) *Weathertight*

Weathertight means that in any sea conditions water will not penetrate into the ship.

REGULATION 3
GROSS TONNAGE

The gross tonnage (GT) of a ship shall be determined by the following formula:

$$GT = K_1 V$$

where

V = Total volume of all enclosed spaces of the ship, cubic metres

$K_1 = 0.2 + 0.02 \log_{10} V$ (or as tabulated in Appendix 2).

REGULATION 4
NET TONNAGE

(1) The net tonnage (NT) of a ship shall be determined by the following formula:

$$NT = K_2 V_c \left(\frac{4d}{3D}\right)^2 + K_3 \left(N_1 + \frac{N_2}{10}\right)$$

in which formula

(a) The factor $\left(\frac{4d}{3D}\right)^2$ shall not be taken as greater than unity

(b) The term $K_2 V_c \left(\frac{4d}{3D}\right)^2$ shall not be taken as less than 0.25 GT

(c) NT shall not be taken as less than 0.30 GT

and in which

V_c = total volume of cargo spaces, cubic metres

$K_2 = 0.2 + 0.02 \log_{10} V_c$ (or as tabulated in Appendix 2)

$K_3 = 1.25 \frac{GT + 10{,}000}{10{,}000}$

D = moulded depth amidships, metres, as defined in Regulation 2(2)

d = moulded draught amidships, metres, as defined in paragraph (2) of this Regulation

N_1 = number of passengers in cabins with not more than 8 berths

N_2 = number of other passengers

$N_1 + N_2$ = total number of passengers the ship is permitted to carry as indicated in the ship's passenger certificate; when $N_1 + N_2$ is less than 13, N_1 and N_2 shall be taken as zero

GT = gross tonnage of the ship as determined in accordance with the provisions of Regulation 3.

(2) The moulded draught (d) referred to in paragraph (1) of this Regulation shall be one of the following draughts:

(a) For ships to which the International Convention on Load Lines in force applies, the draught corresponding to the Summer Load Line (other than timber load lines) assigned in accordance with that Convention.

(b) For passenger ships, the draught corresponding to the deepest subdivision load line assigned in accordance with the International Convention for the Safety of Life at Sea in force or other international agreement where applicable.

(c) For ships to which the International Convention on Load Lines does not apply but which have been assigned a load line in compliance with national requirements, the draught corresponding to the summer load line so assigned.

(d) For ships to which no load line has been assigned but the draught of which is restricted in compliance with national requirements, the maximum permitted draft.

(e) For other ships, 75 percent of the moulded depth amidships as defined in Regulation 2(2).

REGULATION 5
CHANGE OF NET TONNAGE

(1) When the characteristics of a ship, such as V, V_c, d, N_1 or N_2 as defined in Regulations 3 and 4, are altered and where such an alteration results in an increase in its net tonnage as determined in accordance with the provisions of Regulation 4, the net tonnage of the ship corresponding to the new characteristics shall be determined and shall be applied without delay.

(2) A ship to which load lines referred to in subparagraphs (2) (a) and (2) (b) of Regulation 4 are concurrently assigned shall be given only one net tonnage as determined in accordance with the provisions of Regulation 4 and that tonnage shall be the tonnage applicable to the appropriate assigned load line for the trade in which the ship is engaged.

(3) When the characteristics of a ship such as V, V_c, d, N_1 or N_2 as defined in Regulations 3 and 4 are altered or when the appropriate assigned load line referred to in paragraph (2) of this Regulation is altered due to the change of the trade in which the ship is engaged, and where such an alteration results in a decrease in its net tonnage as determined in accordance with the provisions of Regulation 4, a new International Tonnage Certificate (1969) incorporating the net tonnage so determined shall not be issued until twelve months have elapsed from the date on which the current Certificate was issued; provided that this requirement shall not apply:

(a) If the ship is transferred to the flag of another State.

(b) If the ship undergoes alterations or modifications which are deemed by the Administration to be of a major character, such as the removal of a superstructure which requires an alteration of the assigned load line.

(c) To passenger ships which are employed in the carriage of large numbers of unberthed passengers in special trades, such, for example, as the pilgrim trade.

Coefficients K_1 and K_2 Referred to in Regulations 3 and 4(1)

V or V_c = Volume in cubic metres

V or V_c	K_1 or K_2	V or V_c	K_1 or K_2	V or V_c	K_1 or K_2	V or V_c	K_1 or K_2
10	0.2200	45,000	0.2931	330,000	0.3104	670,000	0.3165
20	0.2260	50,000	0.2940	340,000	0.3106	680,000	0.3166
30	0.2295	55,000	0.2948	350,000	0.3109	690,000	0.3168
40	0.2320	60,000	0.2956	360,000	0.3111	700,000	0.3169
50	0.2340	65,000	0.2963	370,000	0.3114	710,000	0.3170
60	0.2356	70,000	0.2969	380,000	0.3116	720,000	0.3171
70	0.2369	75,000	0.2975	390,000	0.3118	730,000	0.3173
80	0.2381	80,000	0.2981	400,000	0.3120	740,000	0.3174
90	0.2391	85,000	0.2986	410,000	0.3123	750,000	0.3175
100	0.2400	90,000	0.2991	420,000	0.3125	760,000	0.3176
200	0.2460	95,000	0.2996	430,000	0.3127	770,000	0.3177
300	0.2495	100,000	0.3000	440,000	0.3129	780,000	0.3178
400	0.2520	110,000	0.3008	450,000	0.3131	790,000	0.3180
500	0.2540	120,000	0.3016	460,000	0.3133	800,000	0.3181
600	0.2556	130,000	0.3023	470,000	0.3134	810,000	0.3182
700	0.2569	140,000	0.3029	480,000	0.3136	820,000	0.3183
800	0.2581	150,000	0.3035	490,000	0.3138	830,000	0.3184
900	0.2591	160,000	0.3041	500,000	0.3140	840,000	0.3185
1,000	0.2600	170,000	0.3046	510,000	0.3142	850,000	0.3186
2,000	0.2660	180,000	0.3051	520,000	0.3143	860,000	0.3187
3,000	0.2695	190,000	0.3056	530,000	0.3145	870,000	0.3188
4,000	0.2720	200,000	0.3060	540,000	0.3146	880,000	0.3189
5,000	0.2740	210,000	0.3064	550,000	0.3148	890,000	0.3190
6,000	0.2756	220,000	0.3068	560,000	0.3150	900,000	0.3191
7,000	0.2769	230,000	0.3072	570,000	0.3151	910,000	0.3192
8,000	0.2781	240,000	0.3076	580,000	0.3153	920,000	0.3193
9,000	0.2791	250,000	0.3080	590,000	0.3154	930,000	0.3194
10,000	0.2800	260,000	0.3083	600,000	0.3156	940,000	0.3195
15,000	0.2835	270,000	0.3086	610,000	0.3157	950,000	0.3196
20,000	0.2860	280,000	0.3089	620,000	0.3158	960,000	0.3196
25,000	0.2880	290,000	0.3092	630,000	0.3160	970,000	0.3197
30,000	0.2895	300,000	0.3095	640,000	0.3161	980,000	0.3198
35,000	0.2909	310,000	0.3098	650,000	0.3163	990.000	0.3199
40,000	0.2920	320,000	0.3101	660,000	0.3164	1,000,000	0.3200

Coefficients K_1 or K_2 at intermediate values of V or V_c shall be obtained by linear interpolation.

Appendix 3

-eference, Recommendation 2 of the Final as follows:

ses of Gross and Net Tonnages

-ence recommends that the gross tonnage onnage as determined in accordance with of the International Convention on Tonments of Ships, 1969, should be accepted ters referred to where those terms are used s, laws and regulations, and also as the basis for statistical data relating to the overall size (useful capacity of merchant ships. In addition, reco| nizing that the transition from existing tonnage measur ment systems to the new system provided in the Co vention should cause the least possible impact on tl economics of merchant shipping and port operation the Conference recommends that Contracting Gover ments, port authorities, and all other agencies which us tonnage as a basis for charges should carefully conside which parameter is most appropriate for their use in th light of their present practice.

Discussion

18

-non, *Visitor:* I would like to refer partic- ›lution 2. It is true that many ports in the ıbly the majority of ports—have been very rough and ready application of the principle. In th first place, with the adoption of the open shelter dec concept it could no longer be said that net tonnage r

COMPENSATED GROSS TONNAGE COEFFICIENTS

Ship Type/Type de Navire	CGRT Coefficient 1977 (IUBC)	CGT Coefficient 1984 (IUC)
A: CARGO SHIPS/CARGOS		
Crude Oil Tankers/Petroliers		
Under 4,000 dwt	2.50	1.70
4- 10,000 dwt	1.80	1.15
10- 30,000 dwt	0.65	0.75
30- 50,000 dwt	0.50	0.60
50- 80,000 dwt	0.45	0.50
80-160,000 dwt	0.40	0.40
160-250,000 dwt	0.35	0.30
250,000 dwt and over	0.30	0.25
Product & Chemical Carriers (4)/Transporteurs de Produits Petroliers et Chimiques		
Under 4,000 dwt	2.50	2.30
4- 10,000 dwt	1.80	1.60
10- 30,000 dwt	0.80	1.00
30- 50,000 dwt	0.60	0.75
50- 80,000 dwt	(0.50)	0.55
80,000 dwt and over	(0.50)	0.50
Bulk Carriers ex Combined Carriers/ Transporteure de Vrac (Transporteurs Combines Exclus)		
Under 4,000 dwt	2.50	1.60
4- 10,000 dwt	1.80	1.10
10- 30,000 dwt	0.60	0.70
30- 50,000 dwt	0.50	0.60
50- 80,000 dwt	(0.45)	0.50
80-160,000 dwt	(0.40)	0.40
160,000 dwt and over	(0.40)	0.30
Combined Carriers/Transporteurs Combines		
Under 4,000 dwt	2.50)	1.60) (1)
4- 10,000 dwt	1.80)	1.10)
10- 30,000 dwt	0.65	0.85
30- 50,000 dwt	0.55	0.70
50- 80,000 dwt	(0.50)	0.55
80-160,000 dwt	(0.45)	0.45
160,000 dwt and over	(0.45)	0.35
General Cargo Ships/Cargos		
Under 4,000 dwt	3.00	1.85
4- 10,000 dwt	1.40	1.35
10- 20,000 dwt	(1.00)	1.00
20- 30,000 dwt	(1.00)	0.85
30- 50,000 dwt	(1.00))	0.70)
50- 80,000 dwt	(1.00))	0.55) (2)
80-160,000 dwt	(1.00))	0.45)
160,000 dwt and over	(1.00))	0.35)
Reefers/Navires Refrigeres		
Under 4,000 dwt	3.00	2.05
4- 10,000 dwt	2.00	1.50
10,000 dwt and over	1.40	1.25

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Ship Type/Type de Navire	CGRT Coefficient 1977 (TUBC)	CGT Coefficient 1984 (TUC)	
A: CARGO SHIPS/CARGOS (cont)			
Full Container Ships (7)/Navires Containeurs (7)			
Under 4,000 dwt	3.00	1.85	(3)
4- 10,000 dwt	1.40	1.20	
10- 20,000 dwt	(0.90)	0.90	
20- 30,000 dwt	(0.90)	0.80	
30- 50,000 dwt	(0.80)	0.75	
50,000 dwt and over	(0.80)	0.65	
Ro-Ro Vessels (8)/Navires Rouliers (8)			
Under 4,000 dwt	3.00	1.50	
4- 10,000 dwt	2.00	1.05	
10- 20,000 dwt	(1.60)	0.80	
20- 30,000 dwt	(1.60)	0.70	
30,000 dwt and over	(1.60)	0.65	
Car Carriers (8)/Transporteurs de Voitures (8)			
Under 4,000 dwt	3.00	1.10	
4- 10,000 dwt	2.00	0.75	
10- 20,000 dwt	(1.60)	0.65	
20- 30,000 dwt	(1.60)	0.55	
30,000 dwt and over	(1.60)	0.45	
LPG (4)/Transporteurs de Gaz de Petrols Liquids (4)			
Under 4,000 dwt	2.50	2.05	
4- 10,000 dwt	1.60	1.60	
10- 20,000 dwt	(1.00)	1.15	
20- 30,000 dwt	(1.00)	0.90	
30- 50,000 dwt	(0.80)	0.80	
50,000 dwt and over	(0.80)	0.70	
LNG Carriers/Transporteurs de Gas Natural Liquids			
Under 4,000 dwt	2.50)	2.05)	
4- 10,000 dwt	1.60)	1.60)	(5)
10- 30,000 dwt	(0.90)	1.15)	
		0.90)	
30- 50,000 dwt	0.70	0.80)	
50,000 dwt and over	0.50	0.60	
B: MISCELLANEOUS VESSELS/NAVIRES DIVERS			
Ferries (6)/Transporteurs de Voitures (6)			
100- 1,000 gt	(2.50)	3.00	
1,000- 3,000 gt	(2.50)	2.25	
3,000-10,000 gt	(2.50)	1.65	
10,000-20,000 gt	(1.50)	1.15	
20,000 gt and over	(1.30)	0.90	
Passenger Ships (6)/Paquebots (6)			
100- 1,000 gt	(1.50)	6.00	
1,000- 3,000 gt	(1.50)	4.00	
3,000-10,000 gt	(1.50)	3.00	
10,000-20,000 gt	(1.50)	2.00	
20,000 gt and over	(1.50)	1.50	
Other Non-Cargo Vessels/Autres-Navires Non Cargos			
Under 100 grt	5.00		
100 - 2,000 grt	3.00		
2,000 grt and over	2.00		

Ship Type/Type de Navire	CGRT Coefficient 1977 (TUBC)	CGT Coefficient 1984 (TUC)
B: MISCELLANEOUS VESSELS/NAVIRES DIVERS (cont)		
Fishing Vessels/Navires de Peche		
100-1,000 gt		4.00
1,000-3,000 gt		3.00
3,000 gt and over		2.00
Others (including tugs dredgers, etc)/Augres (y compris trorquers, drauges, etc)		
100- 1,000 gt		5.00
1,000- 3,000 gt		3.20
3,000-10,000 gt		2.00
10,000 gt and over		1.50

1. Apply same coefficients as "Bulk Carriers"/Appliquer les sames coefficients que "Navires Vracquiers".

2. Apply same coefficients as "Combined Carriers"/Appliquer les sames coefficients que "Transporteurs Combines".

3. Apply same coefficients as "General Cargo"/Appliquer les sames coefficients que "Cargos".

4. In the 1977 system "Chemical carriers" were included in "LPG Carriers"/Dan le systeme de 1977 les "Transporteurs de Produits Chimiques" entant inclus dans "Transporteurs GPL".

5. Apply same coefficients as "LPG Carriers"/Appliquer les sames coefficients que "Transporteurs GPL".

6. CGRT coefficients in force since 1.1 1983/Coefficients CGRT appliques depuis 1.1 1983.

7. In the 1977 system the heading was "Full Container Ships/High Speed Liners"/Dans le systeme de 1977 le titre etait "Navires Containeurs et de lingne rapides".

8. In the 1977 system the heading was "Ro-Ro Vessels/Car Carriers"/Dans le systeme de 1977 le titre etait "Navires Roulers et Transporteurs d'automobiles".

( ) The subdivision did not exist in the 1977 system/Le sous division n'existait pas dan le system de 1977

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MILITARY GROSS TONNAGE AND COMPENSATED GROSS TONNAGE (CGT) COEFFICIENTS

While most military ships do not have national admeasurement applird, they often have Suez and Panama Admeasurement prepared. These tonnages are based on modified Moorsom System of admeasurement and have developed many inequitiies because of different interpretations of international conventions by national governments. Because of this, IMO held a convention in 1970 that agreed on a simplified approach to be applied internationally, and this system came into force in 1984. However, even though it is very simple to calculate, most military ships do not calculate this new Gross Tonnage (GT).

The International Gross Tonnage is simply the volume, in cubic meters, of the enclosed spaces in the hull and deckhouse of a ship multiplied by a coefficient. The coefficient is to convert volume to admeasurement tons (.35), and to keep the new Gross Tonnage as close to the existing Gross Registered Tonnage as possible. The coefficient ranges from .22 for a small boat of 20 cubic meters volume to .32 for a very large ship with 1 million cubic meters volume. Most hydrostatic programs used today will give you this volume if the hull and deckhouse are completely defied into the computer model as is normally done for the stability calculations.

The team was unable to obtain this information from the U.S. military ships from the shipyards visited. They did receive the Gross Tonnages for the Avondale built Fleet Oilers but it is uncertain if they were U.S. or international Gross Tonnages. Although from the low value compared to the estimated value it is believed that they were the old U.S. Gross Registered Tonnage which allows exemption of water ballast spaces and does not include the volume in double bottom.

In order to attempt to develop a productivity measure for U.S. shipyards which could be used to determine competitiveness, Gross Tonnage is required. Estimates of Gross Tonnage were made for a number of recent U.S. and British military ships and are given in Table I.

TABLE I
ESTIMATED GROSS TONNAGE FOR MILITARY SHIPS

FRIGATES	GROSS TONNAGE
British Type 22	4,950
British Type 23	3,800
USA FFG	4,725
DESTROYERS	
British Type 82	6,000
USA DDG 51	8,750
OTHER	
USA AEGIS	8,050
USA LSD	17,700
USA LHD	74,200
USA Aircraft Carriers	108,000
USA Fleet Oiler	25,500 Avondale
USA Fleet Oiler	38,500 NASSCO

The next measure that is required to enable productivity comparison is coefficients to apply to the T to account for the vessel type and size impact on complexity. These have been developed for all types of commercial ships over many years by the OECD and Table II shows the current coefficients. There are no published coefficients for military ships. Therefore, estimates of GT Coefficients were derived from review of suitable (high complexity)cornmercial ship and sizes as well as comparison of building manhours for both military and commercial ships. The estimated GT Coefficients for military ships are shown in Table III. These coefficients were derived from a small sample of relatively small (up to 6,000 GT) commercial and military ships from European and a few U.S sources. The Manhours/Gross Tonnage values were calculated and plotted on log log scale. The plot showed both the fleet oilers and the LSD on a much lower cuwe than the combatant ships. The ratio of the measure for military compared to commercial ships was determined and applied to the Went CGT Coefficients for Ferries and Passenger at different Gross Tonnage. The military combatant line was projected as a straight line to the size of the LHD and Aircraft Carrier.

TABLE III
ESTIMATED CGT COEFFICIENTS FOR MILITARY SHIPS

" Frigates	10 to 18
Destroyers	8 to 14
Cruisers	7 to 12
Aircraft Carrier	2 to 4
LSD	2 to 4
LHD	3 to 5
Fleet Oder	1.5t02

Applying these coefficients to the first of a class of a military support ship, built in a U.S. shipyard in 1984, gives a productivity factor ranging from 74 to 148 MWCGT. These values are well above European and Japanese Shipbuildinjj productivity for complex shiPS of similar size which would be in the low 40's.

It is recommended that individual U.S. shipyards start to use this approach to measure productivity for every ship they are currently building and for all future bids and building. They can start by using the estimated CGT Coefficients in Table III with their calculated Gross Tonnage to determine the productivity factor. This would enable them to refine the coefficients over time and by comparing different ship types in the same shipyard. For example Ingalls Shipbuilding could compare Aegis Cruisers, DDG51 Destroyers, LHA's and LHD's. It would be reasonable to expect lower manhours per CGT values for the larger ships. The results could also be used to record impact of design changes and improved processes.

It is suggested that at a minimum the following measures be derived:

Direct ManhourdCGT
Total Employee Manhours/CGT
CGT/Direct worker Year
CGT/Total Employee Year

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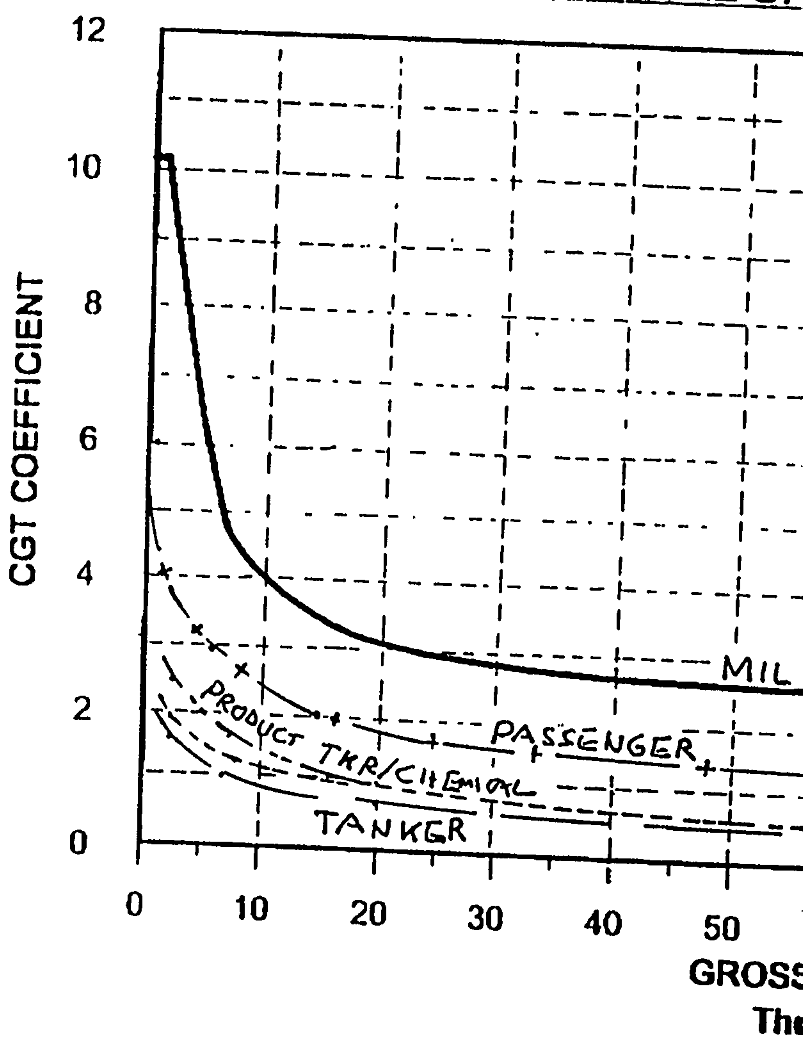
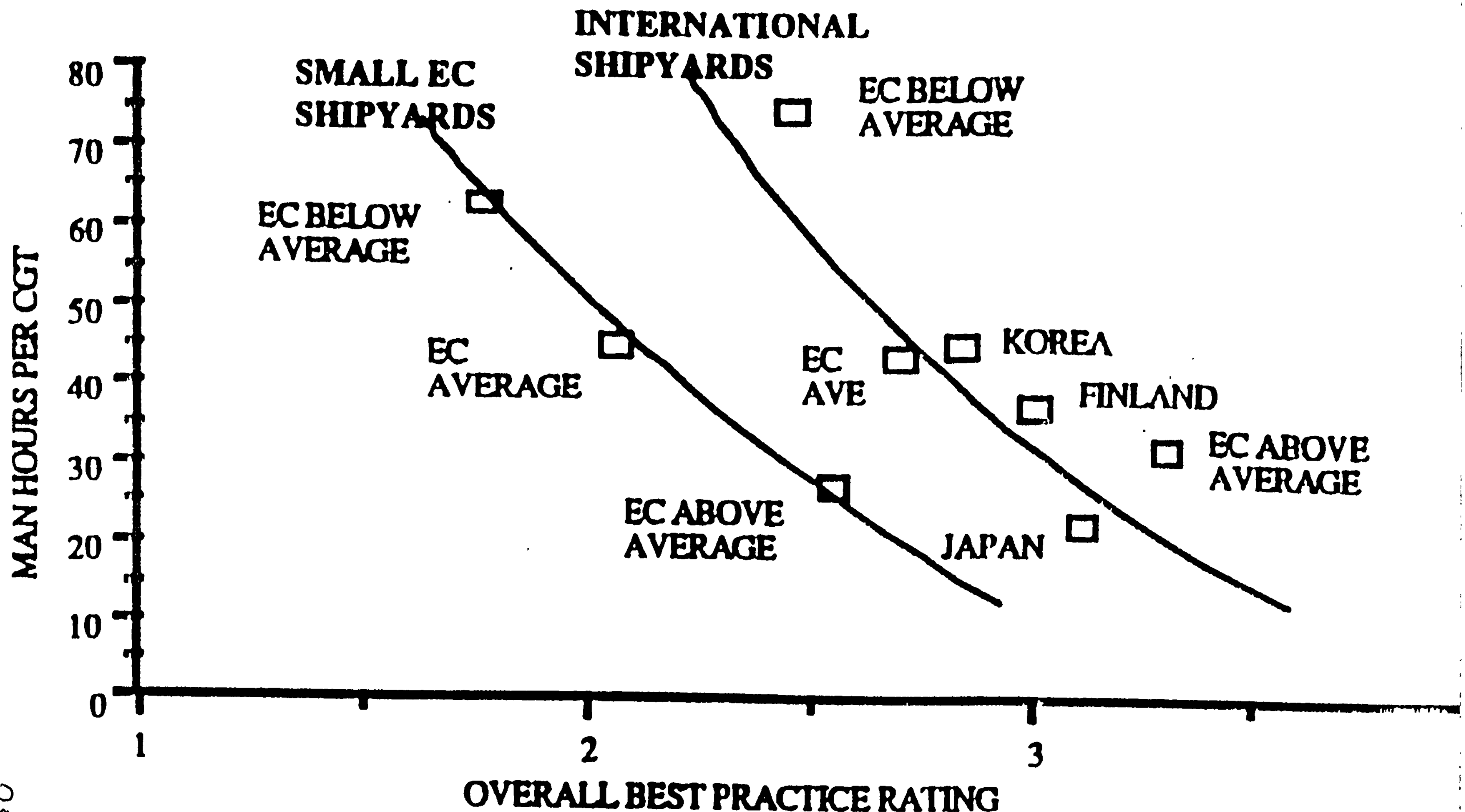
CGT COEFFICIENTS FOR NAVAL SH



Best Practice/Performance Correlation



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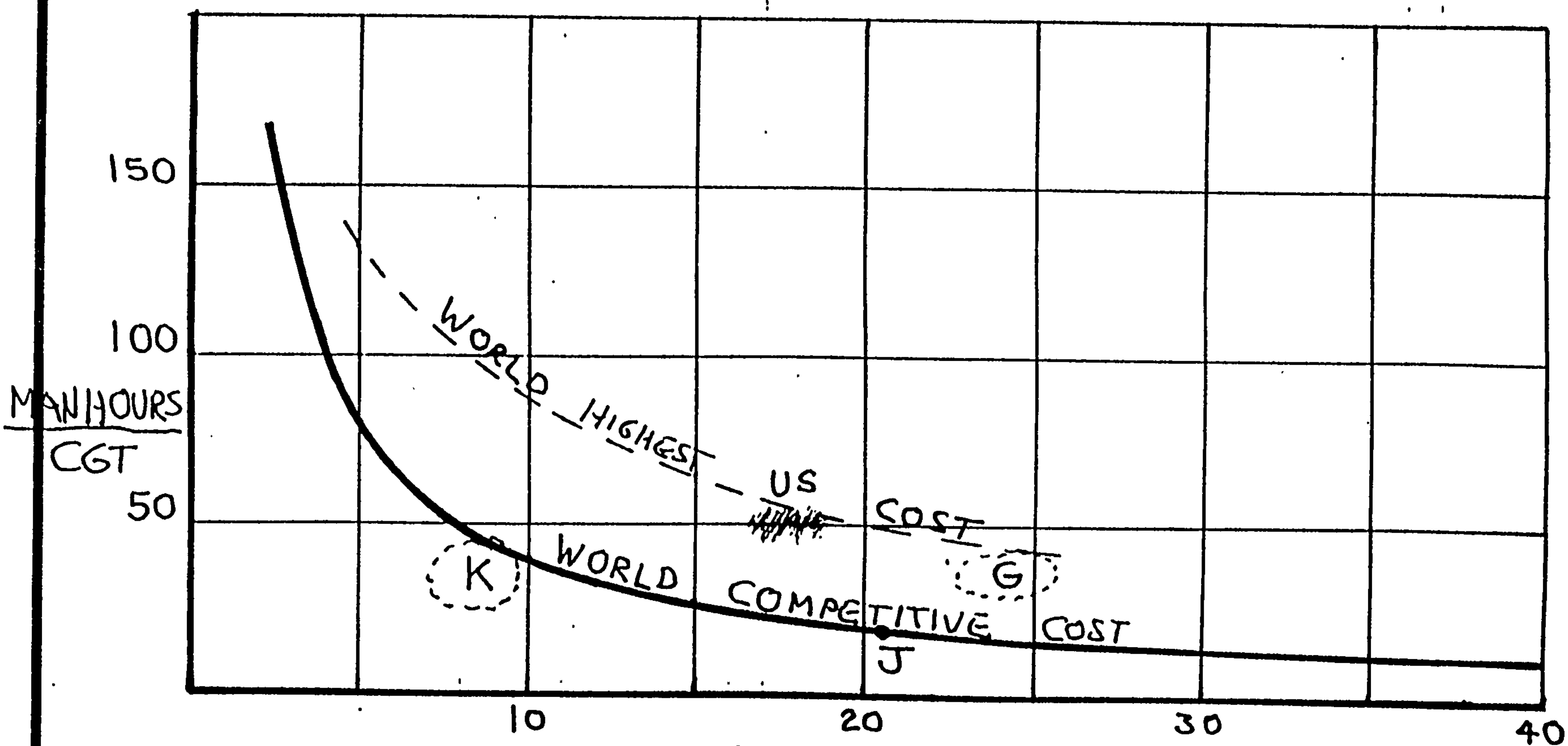
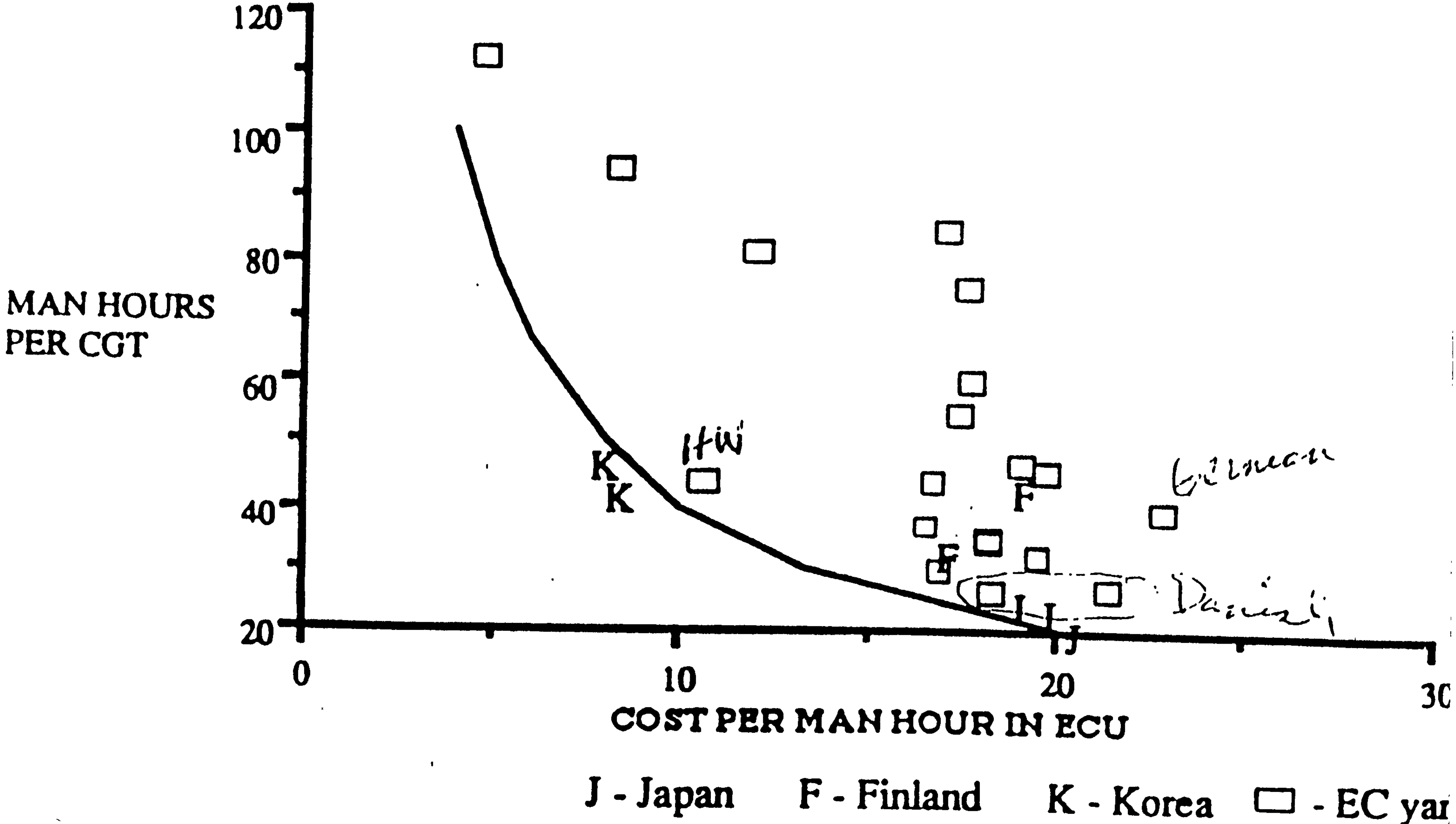


COST PER CGT = COST/MH × MH/CGT

Shipyard labour cost comparisons



DESIGN AND BUILDING CYCLE TIME

SHORT DESIGN AND BUILDING CYCLE TIMES ARE DIRECTLY RELATED TO HIGH ANNUAL OUTPUT, SUCH AS:

4 TO 6 VLCCS
6 TO 8 140,000 TDWT TANKERS AND/OR BULK CARRIERS
4 TO 6 CONTAINERSHIPS

OR

8 PRODUCT TANKERS

SHORT DESIGN AND BUILDING CYCLES ARE ONLY POSSIBLE WITH SUFFICIANT AND CONTINUOUS DEMAND FOR SHIPS.
FOR EXAMPLE: 4 MONTH BERTH TIMES REQUIRE 3 OR MORE SHIP COMPLETIONS PER YEAR

DESIGN AND BUILDING CYCLE TIME (Cont)

CONSTRUCTION TIME - MONTHS (KEEL LAYING TO DELIVERY)

SHIP TYPE	EUROPE	DENMARK	JAPAN	U.S.A.
VLCC	17	5	9	
PRODUCT TANKER	13		8	20
BULK CARRIER	14		8	
CONTAINERSHIP (4400)	17	X 5	9	
CONTAINERSHIP (1880)	12	7		24

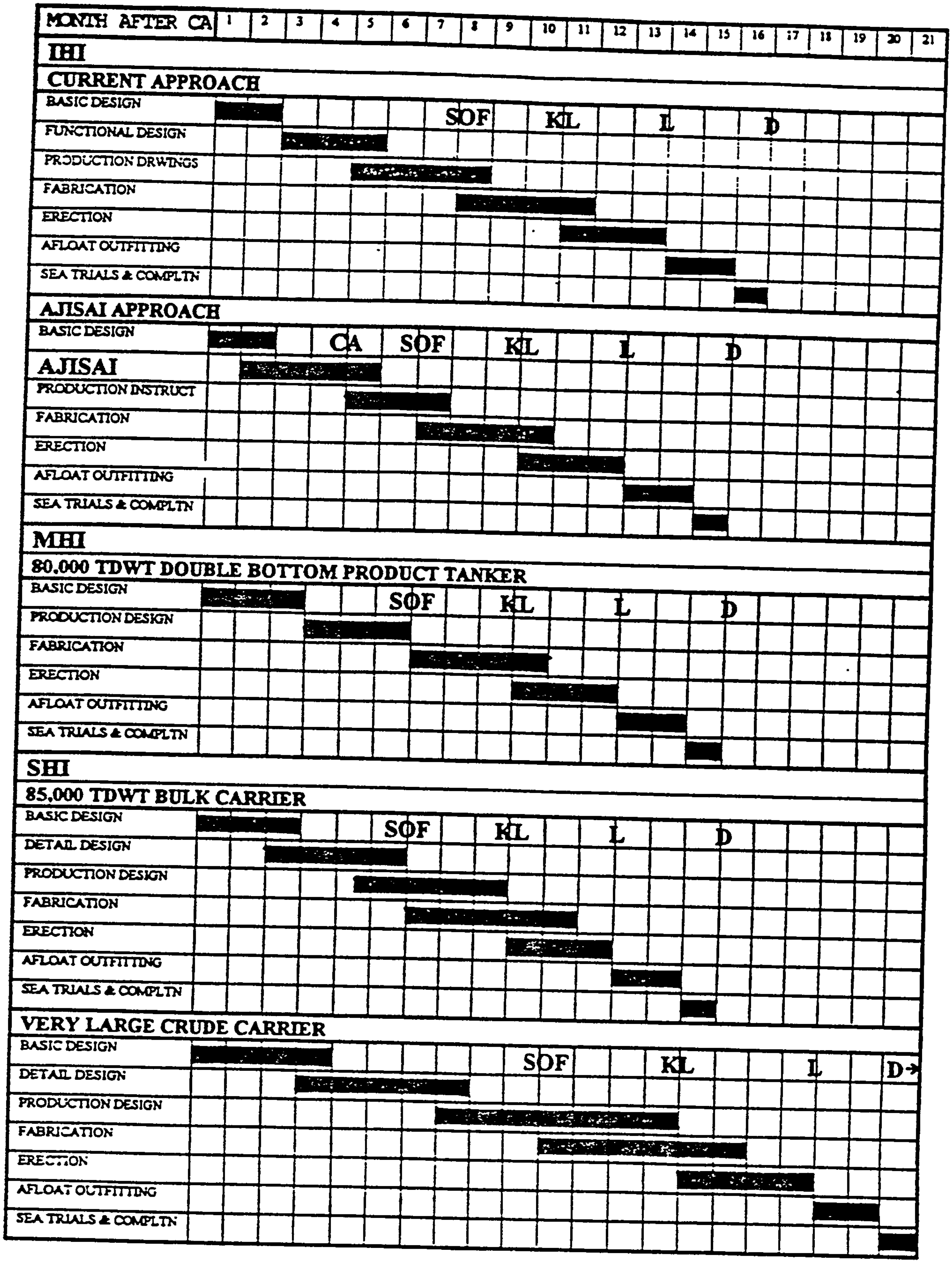


FIGURE 7.1.1 - TYPICAL JAPANESE DESIGN AND BUILD SCHEDULES

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IMPLEMENTING TECHNOLOGY

- IMPLEMENT NEW TECHNOLOGIES IN AN ATTEMPT TO STAY IN FRONT OR AT LEAST STAY WITH THE COMPETITION

- FOR MANY COMPANIES TODAY THIS MEANS MAINTAINING COMPETITIVNESS IN BOTH DOMESTIC AND INTERNATIONAL MARKETS

- TO DO SO IT IS NECESSARY TO ATTAIN WHAT IS GENERALLY REFERED TO AS “WORLD CLASS IN MANUFACTURING PRACTICE?’

- THIS USUALLY INVOLVES BENCHMARKING WITH THE COMPETITION, AND AS THEY HAVE SET THE STARDARD IN MANY INDUSTRIES FOR YEARS, IT USUALLY MEANS COMPARING WITH THE JAPANESE

- MANY PEOPLE HAVE TRIED TO DETERMINE HOW THE WORLD CLASS COMPANIES ACHIEVE THEIR SUCCESS AND THEN TO EMULATE IT OR EVEN IMPROVE ON IT

- MANY WAYS TO ACCOMPLISH THIS HAVE BEEN ATTEMPTED, INCLUDING:

  BENCHMARKING
  TECHNOLOGY TRANSFER
  PARTNERSHIP WITH A RECOGNIZED WORLD CLASS COMPANY
  INWARD INVESTMENT BY A RECOGED WORLD CLASS COMPANY

TECHNOLOGY TRANSFER

- TECHNOLOGY TRANSFER IS NOT NEW
- PROBABLY THE MOST SIGNIFICANT TECHNOLOGY TRASFER IN SHIPBUILDING THIS CENTURY IS NOT THAT FROM JAPAN TO U.S., BUT FROM U.S. TO JAPAN AT THE END OF WORLD WAR II
- IN THE LATE 1960'S THE U.S. TRANSFERED COMPUTER AIDED LOFTING AND N/C BURNING FROM EUROPE
- CURRENT TECHNOLOGY TRANSFER TEAMING INCLUDE:

AVONDALE INDUSTRIES	ASTILLEROS ESPANOLES
BATH IRON WORKS	KVAERNER MASA MITSUI ENGINEERING & SHIPBUILDING
BENDER SHIPBUILDING	MITSUBISHI HEAVY INDUSTRIES
NASSCO	KAWASAKI HEAVY INDUSTRIES
TODD PACIFIC	IHI

TECHNOLOGY TRANSFER (Continued)

- CURRENT AGREEMENTS ARE MORE ALL ENCOMPASSING, COVERINGGUIDANCE AND PARTICIPATION BY THE TRANSFEREE IN ALL PROCESSES FROM NEW SHIP DESIGN AND BID THROUGH DELIVERY

- THIS IS PROBABLY BECAUSE U.S. SHIPBUILDERS NOW RECOGNIZE THAT THEY HAVE TO CHANGE THEIR COMPLETE APPROACH TO ACHIEVE THE IMPROVEMENT LEVELS ARE SEEKING, RATHER THAN THE SPECIFIC PROCESS APPROACH THE PAST WHICH A ONLY HAD LIMITED SUCCESS

- BOTH THE VISIBLE AND INVISIBLE FACTORS OF IMPLEMENTING SOMEONE ELSES TECHNOLOGY MUST BE CONSIDERED. THESE ARE REFLECTED IN A SHIPYARD'S"
  - STRATEGY FOR BUILDING SHIPS
  - ORGANIZATIONAL STRUCTURE
  - METHOD OF OPERATING
  - COOPERATION WITH ITS SUPPLIERS AND SUB-CONTRACTORS

- AN INHERENT LIMITATION OF THIS APPROACHCIS THAT THE LEARNING SHIPYARD CAN ONLY BECOME AS PROFICIENT AS THE TRANSFERRING SHIPYARD

- BECAUSE OF THIS SOME SHIPYARDS PREFER TO WORK WITH SHIPBUILDING CONSULTANTS WHO CAN BRING THEM UP TO DATE WITH THE BEST PRACTICES OF THE WORLD CLASS SHIPBUILDERS. THIS CAN BE MORE RISKY, BUT, IF SUCCESSFUL WILL GIVE A COMPETITIVE ADVANTAGE TO THE CHANGING SHIPYARD

NATIONAL SHIPBUILDING RESEARCH PROGRAM

- PART OF THE SNAME TECHNICAL & RESEARCH PROGRAM
- MANAGED BY AN EXECUTIVE CONTROL BOARD
- CURRENTLY 8 ACTIVE PANELS. ALL MEMBERS ARE VOLUNTEERS
- THE PANELS DEVELOP RESEARCH PROJECT IDEAS THAT ARE SUBMITTED TO AND APPROVED BY THE ECB
- SHORT COURSE IS PART OF AN SP-9 (EDUCATION & TRAINING) PANEL PROJECT
- THE EFFECTIVENESS OF THE PANELS BASED ON THE. AMOUNT OF PROJECT SUBJECTS THAT HAVE BEEN IMPLEMENTED By U.S. SHIPBUILDERS IS DISAPPOINTING
- REASONS FOR LACK OF IMPLEMENTATION INCLUDE:
  - NO KNOWLEDGE OF NSRP AND ITS ACTIVITIES
  - NEVER SEEN ANY REPORTS
  - RESEARCH IS NOT APPLICABLE OR TOO THEORETICAL
  - LACK OF FUNDING TO IMPLEMENT EVEN GOOD APPROACHES
  - NOT ENOUGH SHIPYARD INVOLVEMENT IN PROJECTS

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A Review of Technology Development Implementation, and Strategies for Further Improvement in U.S. Shipbuilding

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ABSTRACT

Over the past two decades US. shipbuilders have amassed a great amount of DATA on the Best Shipbuilding Practices throughout the world through direct technology transfer and the sponsorship of the National ShipbuildingResearch Program.

Many US. shipbuilders have used this knowledge to improve parts of the overall shipbuilding process. Not withstanding these positive yet intermittent achievements much must still be done to integrate all the knowledge into a superior set ofshipbuilding strategies to move U.S shipbuilders into a truly global shipbuilding competitive position. Developing the strategies is obviously just the beginning. Committing to their implementation is essential for success in the marketplace.

The paper stresses the development and implementation of comprehensive strategies for the U.S. shipbuilders by exploring the "Global concepts" of integrated product development, accuracy control, stable processes, variety reduction, throughput improvement and, to make it all happen, re-engneering.

INTRODUCTION

while the U.S. shipbuilding industry may currently beat the bottom of the league for commercial shipbuildling it is at the top of the league when the number of employees in the industry is yardstick It is difficult to get accurate comparable numbers for shipyard employment not only for different countri~ but also for the U.S. Fortunately, it is Sufficient to use rough order of magnitude numbers to substantiate this point

For comparison, data on a number of shipbuilding countries, was collected and is presented in Table I. The table shows that apart from China, in which the shipbuilding industry is state owned,the U.S., in 1994 still had the largest number of employees in private shipyards. However, unless something is done quickly to reverse the current rapid decrease of employment in the U.S. shipbuilding industry, the U.S. will Ml to 30,000 employees by the year 2000, far below the current levels in Korea and Japan. A four fold decrease since 1980.

Table 1- Shipbuilding & Repair Employment Levels In Major Shipbuilding Countries (1,000s)

Country	1990			1994	
	(1)	(2)	(3)	(2)	(3)
US.	175	130	90	107	75
Japan	75		55		53
South Korea	53				
Germany	2s				
spin	33				
china	560				

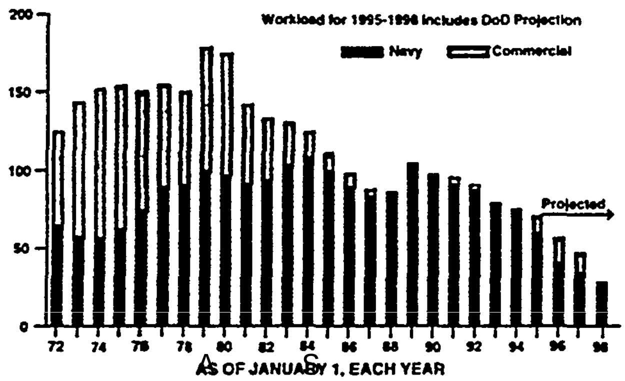
L -UN Industrial Statistics Yearbook 1991
2.- Maritime Adminkaa-041994
3.- Authors estimate for shipbuilding only

The passing of the 1970 act by President Nixon gave a very badly needed impetus to the development and implementation of "advancd shipbuilding technology into U.S. bhipbuilding. Shipyards such as

General Dynamics-Quincy, BethShiP, NASSCO, Newport News and Avondrde all benefited from it Significant achievements were the Livingston Shipyard and Avondale IHI Technology Transfer.

The current National Shipbuilding Research Program (NSRP) developed from seeds planted at this time. The Ship Production Panel SP-2 (outfit Planning) built on these semi-private IHI technology transfers and became the conduit through which IHI ship production technology was transferred to U.S. shipbuilders in general.

In the early 1980's individual shipyard's developed technology transfer arrangements directly with Japanese and European shipbuilders and consultants . However, the demand for commercial ships in the U.S. disappeared when When Reagan eliminated the Construction Differential Subsidy in 1981, and started the 600 ship Navy. Nobody anticipated the coIlapse of the USSR style of communism and the end of the cold war. The resulting peace dividend effect is reflected in the rapid decrease in naval ship demand. Figure 1 shows this clearly as well as why U.S. shipbuilder must get into commercial shipbuilding if they are to survive.



Source - Marine Log

Figure 1- New Commercial and Naval Ships under Construction or on Order in U.S. Shipyards

No U.S. shipyard completely adopted all the proposed improvements. There are many reasons for this including required capital investment for some of them. However, the major reason is simply that they were not buiIding commercial ships. Most shipyards have incorporated many parts of the technologies where they could be of benefit in designing and building Navy combatant and support ships.

Even those planning to enter commercial shipbuilding now, still will not incorporate all the approaches as that would prevent them from being dual purpose shipyards. That is, builders of military and commercial ships in the same facility. Because of this limited adoption of the world class commercial shipbuilding practices, U.S. shipbuilders arc not close to the productivity achieved by the shipyards who are most competitive in international markets.

Interestingly, much of the technology used by world class shipbuilders is not new. It has been around for at least a decade. They have simply kept improving their use of it The Japanese, in particular, change the basic technology of a process only when they have exhausted its potential betits arising from relentless programs of continous improvements.

Has the technology transfer benefited U.S. shipyards? The paper attempts to answer this by comparing two U.S. shipbuilding technology surveys and comparisons with the best foreign shipbuilders. The first performed in the late 1970's (NSRP 1980) and second just completed in 1994 (NSRP 1995). This comparison will give an indication of how far U.S. shipyards have improved and also how much they have closed the gap with the best foreign shipyards.

Next an attempt wilI be made to expIain why so little of the available technology has km adopted by U.S. shipbuilders.

Finally, recommended changes and/or adoption of known tecgnology and the potentiaI benefits -will be given.

GLOBAL SHIPBUILDING MARKET

U.S. shipbuilding status

The current U.S. shipbuilding market consists of naval combatants, naval suppom semi-commercial propositioning military support ships and a smattering of commercial vessels. The commercial vessels are generally highly specialized such as workboats and the mini boom in riverboat casinos. Exceptions to this are the Newport News DOUBLE EAGLE Product Tanker, the Avondale Product Tanker forebodies and the Alabama Drydock chemical carriers.

In 1993, President Clinton proposed a five part program to "Strengthen American Shipyards: A PIan for Competing in the International Market. The plan was based on:

- ensuring fair international competition
- improving commercial competitiveness with MARITECH
- eliminating unnecessary government regulation,

- assisting ship sales through Title XI Loan guarantees of the necessary financing, and
- assisting international marketing.

The first two have been partially accomplished and the third and fourth are underway. Newport News Shipbuilding has secured the order from a foreign ship owner for its Double Eagle Product Tanker and expects more to follow.

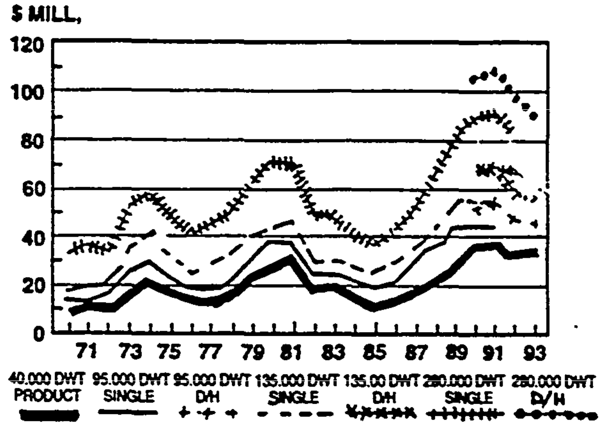
The MARITECH objective is to assist U.S. shipbuilders develop technologies and processes to design and build products that are internationally competitive. This is facilitated by Focused Technology Development Projects, new commercially viable product development, shipyard facility improvement and the establishment of Regional Maritime Technology Centers.

A number of shipyards have commercial ship designs underway which they hope will give them an entry into the world commercial ship market. They range in type from niche ships, such as car carrier/reefers, to commodity container ships and product tankers.

World Shipbuilding Situation

The demand for commercial ships is directly influenced by world trade. From 1962 to 1973 world trade grew at a high annual rate, as did shipping. This is reflected in the growth from 8 million to 34 million Gross Tons (GT) of ships delivered per year from 1962 to 1975. This dropped swiftly to 18 million GT by 1978 and to 13 million by 1980. Since that time, the amount of commercial ships delivered each year has fluctuated from 11 to 18 million GT.

Unfortunately, world shipbuilding capacity continued to increase beyond 1975 due to the coming on line of new shipyards planned during the pre-1975 shipbuilding boom. This over-capacity resulted in the closing of many shipyards, even in Japan. In some countries it resulted in complete elimination of their shipbuilding and support industries. It comes as a surprise to many people that, from the point of view of shipbuilding capacity reduction in GT, Japan had the largest drop, from 18 million to 5 million. More than the total shipbuilding capacity of the rest of the world in 1975. The resulting over capacity has instigated strong price wars. As recently as 1993 world new commercial ship prices were as low as 70% of the average European cost to build them. Figure 2 shows how the price for tankers has fluctuated over the past 24 years and clearly shows the impact of lack of demand on price, even while costs were generally increasing.



Source - Marine Log

Figure 2 - Tanker Historical Prices

However, it should be noted that during this period Japanese and European shipyards have significantly reduced the man hours required to construct ships, as much as 50 % in the case of many of the remaining Japanese shipyards.

Another important factor in the international commercial shipbuilding market is that the world's most successful shipbuilding countries have complete dominance in their domestic ship owning market. Both Japan and Korea build 100% of the ships owned by the ship owners in their respective countries.

The U.S. shipping fleet is one of the oldest in the world at an average age of 21 years. If special ships such as the prepositioning fleet and the Military Sealift ships are excluded the average age increases to 27 years. What a shipbuilding boom the U.S. shipbuilders would have if the U.S. ship owners started to rebuild their ships, in the U.S., that were older than 20 years!

World shipbuilding capacity, at over 30 million GT, is still greater than the demand, although the demand is increasing and it is expected to improve even more as older ships are scrapped and replaced. Unfortunately, this ray of hope for improved ship prices for world shipbuilders may be dimmed by the announced plans to increase existing as well as new shipbuilding capacity in countries such as Germany, South Korea and China, and, of course, the re-entry into commercial shipbuilding of the U.S.

Market Mix/Demand

World market demand for new commercial ships for 1996 is forecasted to be over 25 million GT. The relative market share of different ship types is shown in

Table II which is taken from a paper presented at the 1995 NSRP Symposium (Stott, 1995). Note that the Relative Market Volume is derived by assigning LNG ships the value of unity. That is, for each LNG ship required there are 21.6 container ships The interesting point made in this table is that the best target of opportunity for a shipyard attempting entry into the world commercial shipbuilding market may not be either a niche type or a product tanker, but a bulk carrier or a general cargo ship. Another point is that if a shipyard chooses a niche strategy it will have a low ship throughput even if it is successfulin getting a share of a very small piece of the pie. Figure 3, also from the above referenced paper (Stott 1995), shows that, at least for the moment there is less competition for shipyards that can build large ships, that is ships over S0,000 Tonnes Deadweight

Table II- Ship Type Relative Market Sham

SHIP TYPE	RELATIVE MARKET VOLUME
Bulk carrier	62.3
General cargo	53.5
Tanker	31.5
Container ship	21.6
Fassenger (inCl. Ferries)	17.4
Chemical Tanker	17.1
RO-RO	13.9
	12.8
	5.0
0130	1.3
LNG	Lo

Note -TheRelativeMarket Volume is derivedby assigning a value of one to LNG ships

There is a further complication which arises when assessing demand and this is due to the fact that some markets for building ships are effectively "closed." Examples of this are the Korean and Japanese markets where domestic ship demand is satisfied 100% by national shipbuilders. An assessment therefore has to be made on the size of the "open" market

No matter what strategy is followed, any shipbulder. entering the world commercial shipbuilding market over the next few years, can expect intense competition% and probably low profits, if any.

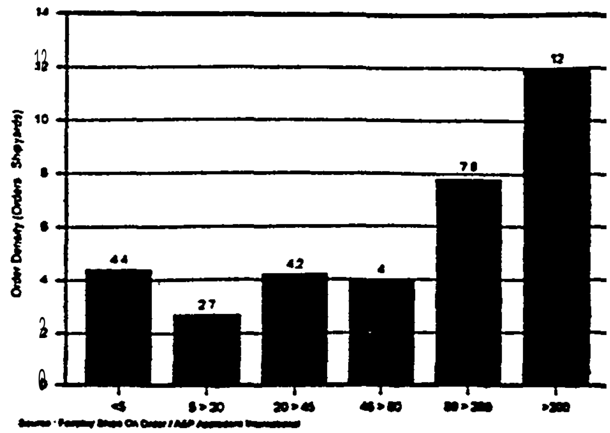


Figure 3- Order Density in Tanker Market

U.S. SHIPBUILDING SITUATION

Competitiveness

Success in the world market requires more than high productivity. Marketing specialists define Competitiveness as product price, place and promotion However, there is no universally accepted definition of competitivemess. KPMG H Marwick in their Study of the Competitiveness of EEC Shipyards (KPMG, 1992), define it as

> "The ability to win and execute shipbuilding orders in open competition and stay in business."

A more measurable definition is that competitiveness is the combined result & price, delivery, quality (customer satisfaction) and financing.

Price is whatever the open market will bear for your product. It is obviously influenced by the balance between demand and supply. Cost which hopefully will be lower than price giving a profit depends on material cost, labor rate and productivity

It is difficult to compare U.S. shipbuilding competitiveness as them has been no international trade commercial shipbuilding in the U.S. for so many years, thus the comparative data is non-existent

Success also depends on other factors such as

- design of products that are most appropriate for their intended use and are reliable in both function and performance,
- carefully targeted,accessible markets,
- attractive financing packages, and
- product guarantees and in service support-

As U.S. shipbuilders focus on commercial ships the need for total implementation of world class commercial shipbuildin best practices times painfully clear. They have to reduce the cost and shorten the design and building time for commercial ships. The dilemma facing them is how to do this in a dual purpose facility? This will be discussed further later.

Compensated Gross Tons (CGT) is used to provide a common measure of the output of commercially shipbuilding in large aggregates such as countries, or regions of the worth. The associated coefficients are the form of stepped functions but with some modifications to remove the steps, CGT can be applied to individual shipyards.

The cost in U.S. dollars of producing a CGT can be used to provide a measure of the competitiveness of shipyards. This measure only relates to the labor cost of producing a CGT and thus relates to the portion of the total cost of a ship which is directly under the control of the shipyard.

The supply chain and associated material cost are an important part of the total ship costs and these need to be addressed..

The 1994 Global Shipbuilding Competitiveness study assessed the competitiveness of the U.S. shipbuilding industry in terms of the cost of producing a CGT compared with the same measure for its competitors. The competitors were the three foreign shipwards involved in the survey as well as other world shipyards considered to be competitors for which comparable data was available. Table III shows the results of this comparison.

Table III - Average Competitiveness Comparison

	U.S. Yards	Visited Foreign	All Foreign
Man HodYear	1,829	1,805	1,963
Man Hours/CGT	185	40	88
cost/Employee Year	$52,500	S63,455	S48,690
cost/cGT	$5,314	$1,121	$1,2%

It is acknowledged that the value for U.S. yards is based on an estimated CGT coefficient but, it would need to be out by a factor of four to bring U.S. shipyard productivity into line with the foreign shipyards and this is unlikely.

Figure 4 shows the relative competitiveness of various shipbuilding countries in terms of Cost/CGT in U.S. dollars, plotted against a background of curves of

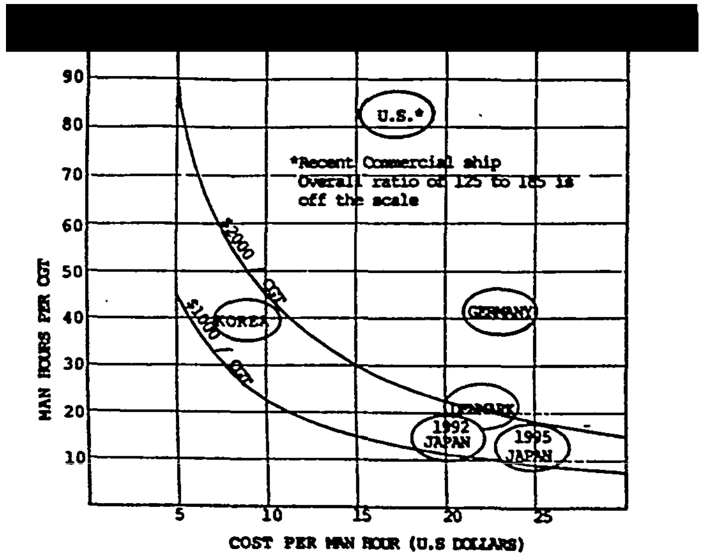


Figure 4- Shipbuilding Competitiveness

constant cost per CGT. The values do not include material costs but area measure of those items under the direct control of the shipyard

Total cost to be considered for international competition is given by:

Exchange Rate X {(FullY Burdened Labor Rate X Labor Hours)+ Material C@

Thus competitiveness is directly influenced by

- Productivity
- Delivery Schedule — shipyard Influenced
- Material cost
- Labor Rates
- Financing
- Exchange Rates — country Influenced
- National Shipbuilding Policy
- Marine industry Infrastructure
- subsidies

Exchange rate is not within the direct control of a shipbuilder and fluctuates all the time. Even the labor rate is only within a little of the shipbuilders control. Therefore, many analysts prefer to consider labor man hours as a relatively stable measure for comparison. This leads to the consideration of productivity.

It can be seen that Productivity is only one of many factors that influence competitiveness. But it is an importantpart as it can be controlled by the shipbuilder. Productivity, in turn, is influenced by the following factors

- Technology
- Facilities
- Management Competence
- WO* Organhtion
- Wofi Praetiee
- Worker Skill Mel
- Worker Motivation

The Global Shipbuilding Competitiveness studies, mentioned above (NSRP, 1995), included a comparison between the previous and latest studies of technology levels. Table IV is such a comparison and it shows that in 16 years the average technology level in U.S. shipyards has increased by 0.9, from 2.5 to 3.4, but the corresponding increase for foreign shipyards was 1.1, from 2.9 to 4.0. That is, the technology gap has widened slightly. The maximum attainable technology level in 1978 was 4.0 while the current maximum level is 5.0. This is due to the technology developments in the time from 1978 to the present

It is equally difficult to get a universally accepted definition of productivity. In the shipbuilding industry, man hours per tonne of steel weight has long been used as a prductivity measure, but it suffers from the fact that ship type, size and complexity are not taken into account and that is not addressed.To overcome this problem the concept of Compensated Gross Ton (COT) was developed in 1%7 by the Association of West European Shipbuilders and the Shipbuilder Association of Japan

The CGTmeasure coefficients to apply to the Gross Tonnage of ships accoutn for their type, size and complexity. These coefficients have been developed over many years through eon between major shipbuilding countries. They cover all commercial ship types.

Man hours per CGT has been accepted as a measure of productivity. A comparative productivity measure used for assessing an individual shipyard's performance is it's labor hours for producing a CGT over a period of 3 to 5 years

How effective is the CGT approach? If it was precise, for different ship types, sizes and complexity constructed in the same shipyard the man hours per CGT would be the same. Table V shows a comparison between man hoursl /tonne of steel and man hours/CGT. It can be seen that there is significant improvement in the COT approach but it still is not precise.

The best international productivity appears to range from 20 MH/CGT for large container ships, 30 MH/CGT for single hull VLCCs,40 MH/CGT for large ferries and 70 MH/CGT for pasenger ships.

COT coefficients are not available for naval ships. Inorder to attempt to derive a rough order of magnitude productivity measure for U.S. shipbuilders in the - Global Shipbuilding Competitiveness study performed for the NSRP SP-4 Panel (NSRP, 1995), CGrT coefficients were estimated for naval ships. These were then applied

Table IV- Survey results Compared to 1994 Survey

GROUP	1978 SURVEY U.S. SHIPYARDS	1978 SURVEY FOREIGN SHIPYARDS	1978 SURVEY DELTA	1994 SURVEY Us. SHIPYARDS	1994 SURVEY FOREIGN SHIPYARDS	1994 SURVEY DELTA
A Steelwork Production	2.25	2.91	0.66	2.91	3.46	0.55
B Outfit Production	2.36	2.43	0.07	3.30	3.75	0.45
C Other Pre–erection Activities	2.06	2.76	0.70	3.83	4.06	0.23
D Ship Construction	2.48	2.86	0.38	3.18	3.98	0.80
E Layout and Environment	2.33	2.89	0.56	2.94	3.31	0.37
G Design/Drafting/Production Engineering	2.92	3.17	0.25	3.45	4.33	0.88
H Organization and Operating systems	2.98	3.03	0.05	4.04	4.67	0.63
OVERALL TECHNOLOGY LEVEL	2.50	2.90	0.40	3.4	4.0	0.60

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Table V-Comparison of Productivity Measures

SHIP TYPE	MH/ST. WT. TONNE	MH/CGT
VLcc	16	32
SuezMax Tanker	19	22
product Tanker	27	20
chemical Tanker	46	36
Bulk Carrier	19	20
Container ship 4400TFEU	19	22
Container ship 1800TFEU	28	22
Reefer	43	34
General Cargo	56	29
Ferry	51	39
Ocean Tug	105	31

to data from a number of U.S. shipyards for naval ships, and the resulting productivity ranged from 180 MH/CGT for a destroyer to 120 MWCGT for a Navy amphibious ship. These values are Significantly worse than European and Japanese shipbuilding productivity values for complex ships.

The Global Shipbuilding competitiveness study also developed an overall measure of U.S. shipbuilding productivity by deriving the total output over the past five years of the shipyards visited in terms of COT and the man hours to produce it. These were 1,683,671 COT and 314,274,641 man hours. The average productivity was therefore 185 man hours CGT. This is higher than the values given above for the destroyer and the amphibious ship, but probably presents a worse case than actually exists,to the fact with that some of the shipyards had "planning yard" and other "white collar" Navy support activities that expend man hours without producing additional output-

Build Cycle Time

Ship build cycle times for U.S. shipbuilder appear to be twice as long as those attained by world Class shipbuilders.

How is it the U.S. cannot match this? The World War II records show that first ship production was achieved by the U.S. So the U.S. has built Ships quickly. What is different today? It is the lack of steady demand for new ships. Many people do not seem to understand that there is a direct relationship between shipyard throughput and productivity and build time. This was shown many years ago by Burmeister & Wain (Sverdrup, 1978). As throughput increases so does productivity and the build time is obviously shortened. Another source has reported that as throughput is increased by 10%, productivity increases by 2 1/2%.

However, it makes no sense to shorten design and build times without an increased continous demand for ships. Even with the improved productivity that will result from the increased throughput it will still be necessary to increase the number of design and production workers and they will need to be mined in the new ways, not the traditional ways, to design fid build ships. This can only be done as a long term investment. It would be ludicrous to man-up for one or two short cycle ship programs and then have to lay off most of the workers because there was no follow on contracts.

The time to deliver a ship after Contract Award Can be divided in to.

Design and Planning
Fabrication
Assembly
Erection
Afloat Completion
Test and Trials

Sometimes when comparing build cycle times it is not clear that the same start stages are used. That is, is the start Contract A war & Start of Desing Startof Fabrication or Keel laying? It is essential that the same activities are being compared. Two cycle times are important from the competitiveness point of view, namely design and construcdon. Typical design time for commercial ships in Europe and Japan range from 6 to 12 months whereas in the U.S. it ranges from 12 to 24 months. Part of the reason for this is that in the U.S. it takes twice the effort as shown in Table VI (Anderson, 1993).

Table VI Typical Design Man Hours

SHIP TYPE	EUROPE/JAPAN	U.S.
VLcc	75,000 Single Hull 102,000 Double Hull	
Product Tanker	34,000	98,000
Bulk Carrier	56,000	
Container ship 4400	72,500	
Container ship 1800	40,000	110,000

Table VII shows typical construction times for different ship types and countries. The data for the U.S. is sparse but it does highlight the problem

Table VII- Construction Time in Months
Keel Laying to Delivery

SHIP TYPE	EUROPE	DENMARK	JAPAN	U.S.
VLcc	17	5	9	
product Tanker	12		8	20
Bulk carrier	16		8	
Container ship 4400	17	8	9	
Container ship 1880	12	12		24

TECHNOLOGY TRANSFER

In the manufacturing industires, it is generally the Japanese companies that have led the world in terms of cost effective production of well designed, reliable, high quality products.

The Japanese approach to low cost manufacturing Canbe [redacted]d as:

1. Designing out of the product needless work of construction.
2. Organizing out of production system needless work of Construction.
3. Avoiding the need for rework.

This is allied to a consistent policy of continuous improvement.

Just how all of this is achieved is the very essence of a Japanese company's method of operation, that evolves overtime in a puposeful, dynamic, well managed manner. For the leading Japanese shipbuilders, this evolution has been underway over the last 40 t0 45 years.

The industrial and commercial performance of Japanese manufacturing have set the benchmarks by which others can measure and compare their own performance. To compete with them in world markets, it is at least necessary to match the combined effect of product features valued by customers, including price, **quality and delivery. Nowhere is this more true than in shipbuilding.**

In many countries the manufacturing companies aim to be competitive in both the domestic and international markets. To do so it is necessary that they become what is generally referred to as "world class in manufacturing practice." This essentially consists of finding out how comparable competitors, usually, but not exclusively, Japanese companies, have achieved their performance, then emulating it by using either the same methods or others that are demonstrably at least equally effective or better.

To date various means of effecting this emulation have been attempted such as

- technology trannsfer,
- partnership with a recognized leader, or
- inward investment by a recognized leader.

In principle any of these methods can be Successful although Success is not guaranteed. There are numerous examples of all three approaches in manufacturing industries in the U.S. In U.S. shipbuilding only technology transfer has been used

Technology transferr is as old as the history of civilization In this century, the most significant in shipbuilding is not that currently underway from Japan and Europe to the U. S., although the importance to the U.S. is certainly the greatest. It is actually the other way around! It was the transfer of shipbuilding technology from U.S. to Japan at the end of World War II,and is well documented by(Chirillo, 1985) and Sasaki, (Sasaki, 1988). Both Claim that this technology transfer was the beginning of what we call today,"Modern shipbuilding and what was Normally labeled the "Americanization of Industry," in the early fifties.

Direct Shipyard to Shipyard or Consultant

U.S. shipyards commenced shipbuilding technology transfer from Europe in the late 1960's in the form of computer aided lofting numerical control burning machines and panel line equipment Newport News Shipbuilding had a technology transfer arrangement with IHI in 1974. Through the support of Maritime Administration (MarAd), Lewingston and Avondale participated in teclumlogy transfer from II-II in 1980 and 1982. Individual shipyards then contracted directly with shipyards and consultants from Japan and Europe. A These direct technology transfer agreements were usually for specific parts of the shipbuilding process, such as material handing planning process analysis accuracy control, production techniques and line heating for plate forming. This incremental or piece-meal approach did not result in the expected significant improvements and sometimes did not achieve the benefits that the original shipyard had anticipated. In hind sight this is probably because it removed the specific approaches out of the total manufacturing system which they worked. The U.S. shipyards into which the new specific item approaches were being introduced did not fully understand the underlying principles and the manufacturing systems in which the approach originated

In many cases, the effectiveness and benefits that different shipbuilders achieve using the same system

can be significantly, even radically different. Because of this disparity, it is necessary to attempt to explain how some shipyards organize and manage to consistently achieve carefully targeted benefits. Much of this is based on the methods developed in Japanese companies, starting in the 50's and applied in some form by the world's most competitive companies. In shipbuilding, most of the methods are described in the reports of the NSRP, (NSRP, 1973-1992). This direct technology transfer has continued and at the present is very active as shown in Table VIII.

Table VIII - Current Technology Transfer Teaming

U.S. SHIPYARD	TECHNOLOGY TRANSFER PARTNER
Avondale Industries	~~IHI~~ ASEA
Bath Iron Works	Kvaerner Masa Mitsui Engineering & Shipbuilding
Bender Shipbuilding	Mitsubishi Heavy Industries
NASSCO	Kawasaki Heavy Industries
Todd Pacific	IHI

Current activities are more all encompassing, covering guidance and participation by the transferee in all the processes from new ship design and bid through delivery. This is probably because the U.S. shipbuilders now recognize that they have to change their complete approach to achieve the improvement levels they are seeking, rather than the specific item approach of the past. Some shipyards have set up consultancy groups such as IHI International division and Kvaerner Masa. Other shipyards such as Kawasaki and Mitsubishi deal directly with the shipyards. There are also shipbuilding consultants with no current relationship with a parent shipyard. U.S. shipbuilders appear to favor the direct shipyard to shipyard technology transfer approach at this time. The transferring shipyard permits visits and benchmarking so that the learning shipyard can see how much it needs to improve. Then the transferring shipyard sends many of its staff to the learning shipyard to train and coach them in the new approaches.

Some leading Japanese shipbuilders, such as IHI and Kawasaki, have supported this type of technology transfer by making available practitioners "on the ground" to show by example and "hand holding" how to perform the practices at the detailed level. This type of hand holding supports the notion that the transfer of technology is best effected by transferring people, permanently or temporarily, with the required experience and ability to train others in the principles and detailed approach to the methods to be introduced. However, quite apart from the highly visible aspects of the technology transfer, that is the processes, there are other factors, largely invisible, that must be considered. Some of these invisible aspects are discussed later in more detail, especially the concepts of stable processes and management of variability. These and much more are reflected in a shipyard's:

- strategy for constructing ships,
- organizational structure,
- general and detailed method of operation, and
- cooperation with its selected suppliers and subcontractors.

An inherent limitation of this approach is that the learning shipyard can only become as proficient as the transferring shipyard. It does not provide an approach to become better than the transferring shipyard. Because of this some shipyards prefer to work with shipbuilding consultants who can bring them up to date in the best practices of world class shipyards and then work with the shipyard to put a complete strategy together combining selected approaches in a holistic way to bring about a superior shipbuilding approach. Obviously, the latter approach is more risky, but, if successful will give a competitive advantage to the shipyard.

National Shipbuilding Research Program

The National Shipbuilding Research Program (NSRP) has been in continuous operation since 1971. It was born out of the 1970 Amendments to the Merchant marine Act, directing the government to create a program to reduce the cost of U.S. commercial ship construction.

In 1988 the Government management role passed from the Maritime Administration to the Navy's David Taylor Research Center. With this was an interest in applying the committee's activity to the improvement of warship production. In 1990 the NSRP goal was changed from "reducing the cost of U.S. shipbuilding" to "making the U.S. shipbuilding industry competitive in the world market."

The NSRP has played a significant part in trying to reach the goal by developing and documenting, through joint government and shipbuilder support, the latest ship production technology and processes, as a way to improve U.S. shipbuilding performance.

The NSRP Ship Production Panels are part of the SNAME Technical and Research Program. An Executive Control Board made up of senior executives from shipbuilding industry, opverseas the operation of the NSRP. Members are volunteers as are all panel members.

Much to the chagrin of smaller shipbuilders, the NSRP is predominantly large ship oriented. This results from the make up of the membership of the panels. The panels had a commercial emphasis from 1980 to 1988. Then a Navy emphasis from 1989 to 1991, when it was again changed back to a commercial emphasis but from the point of view of competing in the global commercial shipbuilding market.

The panels develop research project ideas that are submitted to and approved by the Executive Control Board. Approved projects are funded from the Navy through the panel Program Managers.

The results of the NSRP panel research efforts are disseminated as:

- Panel Reports sent to Company Presidents/CEOs and panel members.
- Papers at NSRP Annual Symposium.
- Papers in the Journal of Ship Production.
- Reports available from University of Michigan Transportation Research Institute Library.

The NSRP has had many successes, including the Annual NSRP Symposium the Journal of Ship Production the Japanese Shipbuilding Technology Transfer Report& the Design for Production Mannual support of the NIDESC Program and actual hardware development/implementation in the areas of welding and surface preparation of steel.

The Output of the ten panels from inception through 1992 can be seen from Table IX.

Table IX- NSRP panel Activity by Number of Reports

PANEL	NUMBER OF REPORTS ISSUED
SP-1 Facilities & Environmental Effects	27
SP-2 Outfitting & Production Aids	34 (15 II-II)
SP-3 Surface Preparation & Coating	55
SP-4 Design/Production Integration	16
SP-5 Human Resource Innovation	12
SP-6 Marine Industry Standards	28
SP-7 Welding	46
SP-8 Industrial Engineering	57
SP-9 Education & Training	14
SP-10 Flexible Automation	3

In 1993, in response to the government sponsored technology reinvestment program the NSRP established its own National Shipbuilding Initiatives, which were to:

- create 250,000 jobs in the shipbuilding and related industries.
- Capture 10% of the world shipbuilding market.
- create high paying jobs.
- Involve all 50 states.
- Create products which a be exported

Unformately, it was not possible to get agreement between the shipyard, NSRP and the Shipbuilders Council and the opportunity to improvement the plan was lost.

Effectiveness

The effectiveness of the technology transfer has been disappointing. While U.S. shipyards have used parts of it such as block construction , zone outfitting, advanced outfitting and Iine heating forrming these have resulted in limited benefits. However, it is probable that the benefits have been at least equal to the cost to perform the technology transfer and development, but the significant leap forward in performance improvement has not occurred This, at least in maybe simply due to the fact that there was no opportunity to apply it all. The technology transferred was for commercial shipbuilding which there has been none in the U.S. during the relevant period. This left the U.S. Shipbuilding to apply the technology where it could be used for naval shipbuilding. Even for naval support ships, such as fleet oilers, it is only of limited application because of the government special requirements compared to commercial ships.

Lack of Implementation

While some of the reasons for not implementing the technology used by world class commercial shipbuilders was discussed above, the more traditional masons need to be considered. Why is change so difficult to implement?

changes in technology can be instigated through educators and/or managers in companies. Technology change through educators teaching students is a long term approach It depends on the student being able to apply new approaches within a company willing to change to bring about improvements. Unforutnately the student, once employed, will not have the position or power necessary to bring about the extent of change required It also depends on the educator being knowledgeable in the best practices world-wide. If a

company is satisfied with the status quo, it is extremely difficult to get anyone with the necessary ability and in+company standing to support and champion change.

The technology transfer that has occurred has been through shipyard managers that interfaced with the transferees or researchers. It has been more of an incremental series of changes than any re-engineering of the shipyard organization.

Also, the extent of this type of change has been constmind by the lack of integration or collaboration between all the traditional functional departments of the shipyard that are involved. That is, the implementation has usually been restricted to the sponsoring department and failed to reap the full benefit because of the lack of support from the other "not involved" departments. This in turn has resulted in many recommended changes becoming file folders in some one's desk never to be opened again after the technology transfer or development is completed.

Much of the details of the technology transfer has not had the full support of the most senior management who seem to have been unwilling to commit to the required changes throughout the company, because of the rquired capital expenditure or the unacceptable changes in management of day to day operations. Technical/lengineenng staff and line management also have been resistant to change.

For a while, in the late 1970's, U.S. shipbuilders added the industrial engineering function into their operations. It was a way to get new approaches introduced into shipbuilding and some of the early implementation of technology transfer was done this way. With the downturn in shipbuilding activity the industrial engineering function has been eliminated in many shipyards. The report "optimal use of IE Techniques in Shipyards," (NSRP, 1989) states "This situation is truly a paradox because the very solution to the problem of gaining these productivity improvements needed to make a shipyard more competitive in the marketplace may well be found ONLY through the application of IE techniques."

A final reason is that it appears most people do not know how to implement change in an organization. To be succesful and to even want to try, requires that individual mindsets and company cultures must be radically changed. This aspect has been addressed by Frankel, (Frankel 1985, and 1992).

The NSRP has undertaken a series of surveys of the implementation of the technology disseminated in their reports and the results have been disappointing. The reasons for this lack of implementation have been documented (NSRP, September and December, 1993) and can be summarized as follows:

- no knowledge of the NSRP activities,
- never seen any reports,
- research not applicable
- lack of funding to implement technology report~
- research too theoretical for shipyards, and
- not enough shipyard involvement in the project development.

SUGGESTED IMPROVEMENTS

It is not possiblee to make improvement suggestions only based on pmxsses and technology. People are an integral part of the processes and the implementation of new technology.

Productivity improvement is a "bottom up" activity. While management must help to foster it by providing the right organization structure, culture, cooperation and support, it requires the drive and willingness of all employees to make the change happen.

A personal Japanese shipbuilder friend of one of the authors told him that even where U.S. shipyards have used new technology, it has failed to attain full potential because of the way U.S. shipyard workers are managed. He suggested that spending money on new technology without spending at least a similar amount on training the people who will use the technology is a complele waste of money and time. With this in mind the first improvement to be discussed is the better use of shipywd workers.

Management and Human Resources

U.S. shipbuilding top management must commit to and participate in implementing the radical change that is quired to achieve competiveness with the rest of the world shipbuilders. The most difficult area to change but one that must be changed is themselves! Next in importance is the people working for them. Implementing new equipment and processes,wihthout corresponding new approach to people, will only result in original improvement if any. What is needed is a quantum leap improvement and that is only possible by radical change in management style and in their use of people.

This is not impossible. Many U.S. companies in other industries are doing this and their successes are well documented (Pfeffer, 1994) However, the changes they have made are revolutionary not incremental and they almost all depend on better partnerships with all their employees.

U.S. shipbuilding managers will need to learn these revolutionary people changes and develop ways to implement them in a very tradition, low trust,and

low worker skill industry. Those U.S. shipbuilders that do this will be the ones that will still around at the beginning of the next millennium. Experience has shown that the extent of the necessary change, may not be achievable by insiders. It usually needs new eyes, thoughts, perspectives, in effect new Paradigms, and these come from the outside (Barker, 1993).

An equally difficult decision that U.S. shipbuilders must face is whether or not they are willing to become a dedicated commercial shipbuilder and give up the role of a dual purpose, Navy and comm- shipyad Ask any foreign shipbuilder if it is possible to be successfd in the global commercial shipbuilding market as a dual purpose shipyard and they will categorically state a loud "NO," especially the ones who tried and are now out of business. This has been tried over and over and the list of those that tried and failed is well known. Even when there has been a clear division between naval and commercial operations within the same facility it has not worked. From Japanese experience it may appear that a dedicated shipyard among a group of shipyards in the same company is an acceptable way to go. However, the Japanese will tell you that it is a necessity not a desire and that the producdivity of the shipyard in which naval ships are built is not competitive in the global shipbuilding markte This fact must be addressed by U.S. shipbuilding management and their decision made.

It must also be addressed by the U.S. government If they want the country's major shipyards to be dual purpose shipyards they must recognize that they can never become competitive in the global commercial Shipbuilding market and be prepared to support them financially to make them so by offsetting the difference in actual and competitive prices.

Typical world class commercial shipbuilders have an average of 1300 production workers and at an average produdivity of 30 MH/CGT deliver 84,500 CGT of ships each year. This is equivalent to 4 1/2 40,000 TDWT Product Tankers each year. Another way to look at it is that the above mentioned NSRP goal to capture 10% of the world commercial shipbuilding would need 200 ships of an average size of 10,000 COT per year to be constructed in U.S. shipyards. At an average productivity level of 50 MWCGT, this would require 40,000 production workers, but in 25 to 30 different shipyards! This is certainly not being planned. A more realistic basis may be to consider 10 shipyards each delivering 2 average commercial ships per year. This would require about 5,000 production workers in the 10 shipyards.

In the U.S. naval shipbuilding is still and is expected to be the player with commercial shipbuilding to fill in the hollows in the naval ship demand. Unfortunately, until this attitude is changed and a sincere ratio to be successful in the international commercial shipbuilding market replaces it, for its own Sake it will Her be achieved.

Most U.S. shipyards' strategy is to obtain commercial orders to supplement dwindling naval shipbuilding and as a way to retain skills needed for naval shipbuilding. Yet,when one realizes that, in general commercial ships require only an eighth of the manpower used on a typical naval ship and must be completed in a quarter of the time, it will take a"lot of them to achieve their strategy.

It is suggested that existing large shipyards over 5,000 employees, that want to succesfully compete in the international commercial shipbuilding market, will need to set up a separate commercial shipbuilding group within their organizations.Even this may not attain the goal as the emphasis will still be mainly on the naval shipbuilding business due to the difference in employee numbers alone, that is 5,000 versus 500.

Processes

There is considerable benefit to be gained from applying "would class" or "Best Practice"shipbuilding processes in a collaborative and integrated way. There are a number of ways that this can be accomplished. U.S. shipbuilders can reduce cost, improve quality and shorten design and build time by applying the Integrated Product Development (IPD), or, as some people know it.,Consurrent .Engineering, & approach and wmciatd tools such as Build Strategies, Product Work Breakdown Structures (PWBS), and 3D Product Models. These are purported to be the best targets for the leverage needed to bring about the vast improvements needed for U.S. shipbuilders to become internationally competitive in the commercial shipbuilding market For these to be successfully implemented the use of accuracy control stable processes, variety reduction and throughput improvement are essential Each of these approaches applied on its own or into existing shipyard organizations without changes will not achieve that goal. This is where Re-engineering can help.

Intemated Product Development(ED}

IPD is more than parallel development. It is a totally integrated. concurrent development using cross-functional teams. The essential tenants of IPD are customer focus, life cycle emphasis and the acceptan of design ownership and commitment by all team members. There is no engineering production or

purchasing problem Each problem in any area becomes the problem of the whale team

IPD is not new. The approach has been used by many companies world wide for some time. In the early 1990's Ingalls Shipbuilding utilized IPD for the design and construction for the SA'AR 5 Corvette (Lindgren, 1992). Nemport News Shipbuilding use IPD on a number Of developmental projects (Blake,]993). Prior to that General Dynamics claim to have used elements of IPD approach for submarine design from 1950 (Bergeson,1993), and based on this experience, when they embarked on their LNG program they succesfully used the IPD approach

The results of the successful use of the IPD approach can be of the radical nature required by U.S. shipyards to beam competitive in the international commercial Shipbuilding market. Customer satisfaction has been improved by 100% cost reduced by 30% and reduction in design and construction time of 50% Interest in IPD by U.S. shipbuilders has peaked this year through the NSRP Concurrent Engineering project involving a one year pilot implementation by Bath Iron Works, where it piggy-backed the pilot implementation onto a real design project, namely the MARTEHC Focused Technology Development Project. A workshop was held in June to transferr their findings and experience to all the U.S. marine industry. Also the Navy sponsored Mid Term Fast Sealift Ship program is utilizing IPD in the development of the Engine Room hangement (digital) Model. Even though this is a process approach, its success depends on the willingness of people in an organization (top to bottom) to change the Wily they think and behave.

Build Strategy

A Build Strategy is much more than the normal planning and scheduling and a desription of how the Production Department will build the ship.

Many shipbuilders use the term "BuiId Strategy" for what is only their Production Plan. The term "Build Strategy" has a special, specific meaning namely,

A Build Strategy is an agreed design, engineering, material management, production and testing plan, prepared before work starts, with the aim of identifying and integrating all necessayprocesses.

A world class shipyard will have designed its facilities around a specific product range and standard production methods which are supported by a variety of technical and administrative functions that have been developed according to the requimnents of production and detailed in a Shipbuilding Policy. In this case, when new orders are received only work which is significantly different from any previously undertaken needs to be investigated in depth in order to identify possible difficulties.

A Build Strategy is a uniquew shipbuilding tool It provides a holistic beginning to end perspective for the project. development schedule. It is also an effective way of capturing the combined design and shipbuilding knowledge and promises, so they can be continuously improved updated, and used as training tools.

The objectives of the Build Strategy Documnt re as follow:

- To identify the new vessel
- To identify the design and features of the new vessel
- To identify contractual ad management targets.
- To identify departure from the shipyard's shipbuilding Policy.
- To identify constraints, based on the new vessel being designed/constructed particularly with reference to other work underway or envisaged.
- To identify what must be done to overcome the above conatraints.

The Iast objective particdarly important as decisions taken in One department will have implications for many others. This means that effective interdepartmental communication is vital

Producing a BuiId Strategy Document will not guarantee an improvement in productivity, although as stated earlier, the process of producing the document will have many benefits. Full benefits will only be gained if the strategy is implemented and adhered to.

A Build Strategy could be produced as a stand alone document for any ship to be built by a shipyard but it would be a great deal thicker and would take a lot more effort to produce if certain other documnents had not been prepared earlier.

The first of these documents would be the Shipyard's Business Plan, which probably exist in most shipyards. A Business Plan sets out the shipyard's ambitions, in terms of desired product range, output and build cycles for a period of years and described how the shipyard aims to attain them.

Next a Shipbuilding Policy should be in place. The policy defines the product mix which the shipyard intends to build plus the optimum organization and procedures which will allow it to produce ships efficiently. The Shipbuilding Policy will address:

- facilities development
- Productivity targets,
- production organization and methods,
- planning and contract procedure, and
- make-buy and subcontractor policy.

The Shipbuilding Policy will also include methods for breaking the ships in the product mix into standard interim products by applying a Product Work Breakdown Structure, (PWBS). Areas in which the interim products wilI be produced and the tools and procedures to be used will also be defined. A major objective of the Shipbuilding Policy is design rationalization and standardization This is achieved by the application of Group Technology and the PWBS to form families of interim products having similar manufacturing requirements.

Ideally, a Ship Definition will also exist. The ship definition must reflect the manner in which the work is to be performed and make full use of the physical and procedural standards that have been adopted. The ship definition specifies the format and content that the engineering information will take in order to support the manner in which the ships will be built The engineering information provided to the production department should only include that necessary for them to perform the work in the assigned work stations.

The relationship between a Business Plan, Shipbuilding policy and Build Strategy is shown in **Figure 5.**

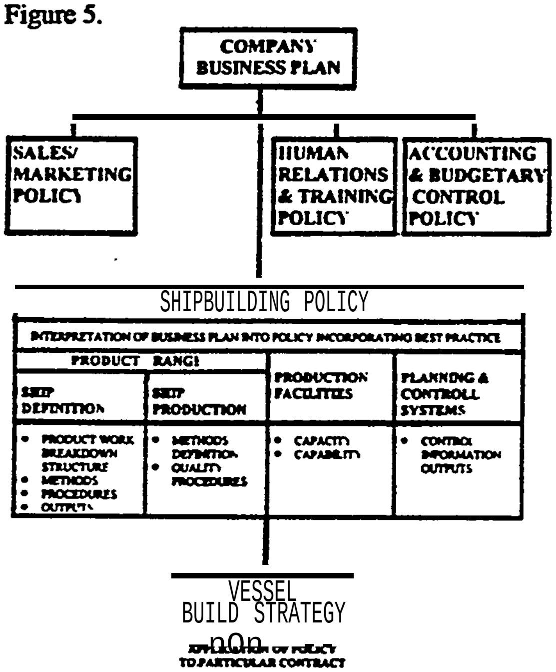

Figure 5- Relationship of Business Plan, Shipbuilding Policy and Build Strategy

<u>product work Breakdown Structure (PWBS)</u>

The design and construction of commercial ships has significantly changed over the past two decades. Most Shipbuilders use structural block and outfitting zone design and construction techniques. An essential prerequisite for successful block and zone approach is the use of Product Work Breakdown Structures (PWBS5). An SP-2 publication outlined their need use and the exprience of Japanese shipyards (NSRP, 1983).

The best knownl Work Breakdown Structure (WIN) in the U.S. shipbuilding community is the Navy's Ship Work Breakdown Structure. MarAd had a similar WBS fm their progmrams. These systems were developed for the Navy's and MarAd's own purposes and not for the shipbuilder. Neither system lends itself to modern shipbuilding approaches. In fact some users say they constrain them.

In are report examining Performance Measurement (NSRP, 1993) the need for a PWBS was clearly established. It first stated that "establishing meaning/id process performance measurement trends is a fundamental prerequisite for continuous improvement," and "without a production oreiented PWBS it is impossible to develop performance measures that are useful in attempting improvements in cost, schedule and Productivity. "Unfortunaately many U.S. shipyards still define their work elements using a ship system based WBS rather than a product based WBS. It is very difficult to effectively and accurately budget, schedule and progress a ship system, because a ship system is not an actual entity that employees handle in a shipyard.

Ideally, a PWBS should be the integrating means by which for all other necessary processes used for the design, material definition material procurement, planning construction and testing of ships Can be harmonized As such it should form the basis for:

- Drawing Identification
- Manufactured and Purchased Part Identification
- Bill of Material Identification
- Purchase Specification Identification
- Structural Party Sub-assembly, Assembly, Block and Grand Block Identification
- Zone and Sub-zone Identification
- Work Package Identification
- Work Sequence Identification
- Material Kit Identification
- Activity Scheduling
- Material Control
- Production Control
- Labor Planning
- Labor Charging

- Measuring Performance, and
- many other systems

It should be clear from the above that the development and implementation of an integrated PWBS is part of the essential start of any attempt to improve the performance of any shipbuilding company.

Accuracy Control

The Japanese claim that one of the foundations of their shipbuilding success is controlled geometric accuracy of all physical output. Without it they would not have been able to achieve the accuracy of fit-up that is necessary to assemble interim products, such as all types and levels of assemblies and equipment units into large, outfitted blocks, which could be erected and joined without extensive fit-up adjustments and rework. It also formed an important part of the basis for their continuous improvement through analysis of production processes.

Accuracy Control is the application of statistical methods to the improvement of product quality in the shipbuilding industry. Unfortunately, many shipbuilders confuse it with Quality Control.

This is surprising as it has been well documented in many publications. Because of this only dthemajorrtibe~ The concept was first introduced to the U.S. shipbuilders in an NSRP report (NSRP, 1982). A major tenant of accuracy control is self-checking by the process operators.

some U.S. shipyards approach to implementing accuracy control is to set up separate accuracy control departments rather than ensure that it becomes everyones job. The quality control mentality is difficult to overcome. Accuracy control must be integrated into every aspect of design, planning and production and not be set up as a separate department. This will help to eliminate the confusion between accuracy control and quality control.

Accuracy control strives to improve first time quality and thus eliminate downstream rework. It does this by analyzing variation in all the ship prediction processes, establishing acceptable tolerances through merging the sequential processes, and then using accuracy control charts as self-monitoring tools by the workers for the processes. It identifies when processes, and the equipment used in the precess, are out of control and in need of improvement and maintenance/replacement.

Stable Processes

To be successful a shipbuilder must be able to estimate accurately the detailed make up of the total resources, and the elapsed time, required to build ships.

To improve competitiveness and thus increase the probability of success, it is also necssary to reduce both cost and elapsed time by effecting significant improvements in terms of product design, and/or the structure and processes of production

Shipbuilders can achieve these goals reliably and consistently by ensuring that all their manufacturing and business prccesses are designed and operated to be stable.

"Within tolerance" stability of all processes is the target that needs to be consistently achieved.

The statistical measures of all the resources used, human, material, monetary, and elapsed time, and the quantity of output achieved for each process, provide part of the necessary feedback This information is the essential basis for:

- making design trade-offs,
- reliably estimating costs in terms of operator hours, elapsed time, consumables, etc.,
- preparing man hour loadings,
- Preparing schedules, and
- identifying opportunities for and evaluating Proposals to effect improvements.

Stable processes are the essence of viable, productive manufacturing and other, systems. This is because the parameters of the outputs of such processes are predictable. On such a basis the future can be predicted and managed with more confidence of success. Predictability is not possible without the inherent orderliness of stable processes. Traditional shipbuilding processes, from design to delivery, are notoriously unstable, especially in terms of the predictability of the resources required to achieve their intended output.

Stability of processes is achieved by:

- Standardizing the working methods to be used consistently by the process operators.
- Training the team of process operators to enable them to apply these standardize methods effectively and consistently.
- Ensuring that changes to the working procdures and methods are only permitted if they have been fully evaluated and approved by appropriate Oprators.
- All equipment should be maintained to the level defined by the equipment/system supplier and necessary to achieve the accuracy control plan
- Consistent application of a PWBS.

- Consistent application of the principles of group technology as a basis for organizing and equipping process lines, workstations, etc.
- Use of the last two items as a basis for organizing the processes to achieve the outputs of specific group technology type intermediate products.

Achieving stability of processes in any industry is difficult. In shipbuilding it is especially difficult because of the low number of identical products. Despite this, stable processes are essential to achieving international shipbuilding competitiveness

As recommended in the reports "Product Work Breakdown Structure," (NSRP, 1982) and "Pipe Piece Family Manufacturing" (NSRP, 1982) processes are orchestrated on the basis of GT practices whereby interim products, the outputs of each process stage, me classified by the common problems involved in their manufacture and produced in the same fashion and for which there is an agreed set of standardize methods and procedures thus supporting stable processes.

Variety Reduction

Excessive variety in product design is expensive to cope with Inadequately managed, it undermines competitiveness.

Managing variety Satisfactorily can be accomplished by the rational deliberate use of two strategies. One that contains and limits the proliferation of variety and the other that increases the ability to handle this contained variety. When equilibrium of the two resulting varieties occurs control is possible. Without equilibrium, organizational entropy increases and operations get out of control. Usually, in such circumstances many things go wrong crisis's occur and a "fire-fighting" style of management is invoked to deal with the problems and restore some semblance of order and control. Inevitably the latter is only temporary.

The foregoing informal description is more formally defined as Ashby's cybernetic Law of Requisite Variety. In general, it is necessary to use an attenuating strategy to reduce variety that must be managed, and an amplifying strategy to increase the ability to manage variety. When these two resulting varieties are equal, Ashby's Law is satisfied and control is achieved

Typical attenuating strategies used to reduce variety include

- standardization of physical things and procedures,
- replacing continuous sizing that contain an infinity of choices with a rationally designed step function that permits only a limited number of size options,
- sets of criteria that are used to cope with specific issues such as those used to judge the worth whileness or otherwise of responding to an inquiry for a ship which would involve preparing a comprehensive but expensive bid package
- Selecting which Ship markets to target rather than try to offer all types,
- developing and marketing a portfolio of fully evaluated standard ship designs that are carefully targeted at the selected market sectors, and
- reducing the number of potential suppliers to a few Carefully selected Companies, then establishing mutual supportive operational practices with them.

Typical amplifying strategies used to increase the ability to handle variety include:

- investment in facilities,
- investment in new technology such as panel lines, robotic welders, etc.,
- recruitment of additional employees,
- hiring temporary employees who have specific skills,
- increase the use of sub-contractors,
- joint ventures or strategic partnerships with carefully selected companies, and
- Use of macro part programs in the context of numerically controlled cutting of discrete structural piece parts.

Consideration of these types of problems have led to new approache a to the design of stadard ships, two of which were developed during the period from 19!32-1994.

The first, initially launched in the spring of 1992 by the German shipbuilder Flensburger Schiffbau Gesellschaft, in response to the new owner of the shipyard giving the employees and management the ultimatum to become internationally competitive in 3 years or he would close the shipyard, developed the ECOBOX family of 12 designs. As a family the different models sham a great deal of commonalty. It is an interesting and admirable case of careful management in the control of variety in the design of a portfolio of ships that are both market friendly and production friendly.

The second was proposed by some of the leading shipbuilders in Japan in 1993. It is one of a set of strategies to cope with the recent steep appreciation of the Yen against other currencies. In essence, the shipyards, in cooperation with the appropriate ship owners operating ships in specific trades, agreed to design a standard ship for those trades. The

shipbuilders then simply compete on price and delivery. It is anticipated that the initial candidate ships types will be those with simple operational requirements, such as those transporting raw materials to Japan. As in most cases of Japanese product innovation they are first tried out in the domestic context before being offered for export. It is worth noting again, that the Japanese merchant marine is the largest in the world, and has been to date, constructed exclusively by Japanese shipbuilder.

World class shipbuilder have learned the foregoing lessons. However, many others continue to offer more-or-less complete customization Management needs to maintain a constant vigilance so that rampant, proliferating variety is not allowed to occur.

Throughput

Throughput is the rate (how many ships Per year) or cycle time (how many months from contract to delivery) at which a shipyard can design and construct ships. However, throughput improvement not only seeks to increase the rate or decrease the time but also to reduce the cost by improved productivity. This is a very general measure and it can be improved by again considering CGT/year as the measure of throughput and MH/CGT as the measure of productivity.

An ongoing NSRP project on throughput improvement (NSRP, 1995) suggested that the throughput of a shipyard can be improved by a four step approach, namely;

1. Total Process Evalution,
2. Elemental Process Improvement
3. Process Integration, and
4. Continuous Process Improvement.

It is suggested that the fourth step is really an approach of which the other three steps are a part. Throughput analysis involves all shipyard departments and this can be supported by clearly defining their roles and requirements in a Shipbuilding Policy. Actually IPD, Build Strategy and Shipbuilding Policy are all excellent tools that can be used for throughput improvement.

A way to identify, measure and support process improvement is needed. It is also necessary to identify in step 1 which processes are the furthest below the best practice level. The goal of the throughput improvement must also be decided in step 1. It can be to Meet the Budget, Beat the Budget or Attain World Class productivity, Quality and Build time. These require different effort and commitments by top management to achieve them, such as Remove Constraints, Incremental Improvement and Re-engineering respectively.

Re-engineering

"Re-engineering is the radical redesign of strategic, value-added business processes, and the systems, policies, and organization structures that support them, to optimize the work flows and productivity in an organization, " (Manganelli, 1994). The emphasis on strategic and value-added process redesign is so that only the processes that are of essential importance to an organization are given consideration

The basic tenants of re-engineering is that it uses "discontinuous thinking", that is Identifying and abandoning the outdated and fundamental assumptions, old Paradigms, that underlie current operations. It is a holistic approach empowering people and leveraging technology.

Re-engineering is not an approach that is undertaken with enthusiasm. Most companies undertake it because competition is threatening their Survival. To claim that U.S. shipbuilders must undertake radical change in the way they work may appear extreme, but it is based on two facts:

1. There is no other approach that will provide the large leap in performance improvement that is required.
2. It has been successfully accomplished by a number of U.S. companies.

How is re-engineering different from other people oriented and technology oriented approaches that arc currently in vogue? Table X is taken from the above referenced book (Manganelli, 1994) and gives a useful comparison of re-engineering with the different approaches.

Work process change and technology breakthrough are not new. What is new is the systematic method for achieving significant improvement through work process change and this is what re-engineering does Lessons learned from many successful and unsuccessful implementations are:

- top management must be willing and committed to apply changes to their operation,
- must have clear and meaningful vision before you start changing
- there are more resistors than supporters of the changes, so top management sponsorship is essential,
- it will not be easy so perseverance is a must
- change agent will probably be an outsider or, if within the company, a radical, and

TABLE X - Re-engineering versus other Approaches

APPROACH / ATTRIBUTE	Re-engineering	Rightsizing	Re-structuring	TQM	Automation
Assumptions Questioned	Fundamental	Staffing	Reporting Relation-ships	Customer Wants and Needs	Technology Applications
Scope of Change	Radical	Staffing, Job ResPonsibil-ities	Organization	Bottom-up	Systems
Orientation	**Process**	Functional	Functional	Process	Procedures
Improvement Goals	Dramatic	Incremental	Incremental	Incremental	Incremmental

Žradical improvement is possible. Improvement Cost **factors of 3 to 5 are attainable and a factor of 30 has been achieved, but not yet in shipbuilding**

Re-engineering because of its radical nature, even more so than incremental change, requires a discipline and framework which can Clearly and reasonably present the case for the proposed changes. No one in their right mind is going to "bet the company" on an idea, no matter how good it is.

Facilities

It is not suggested that U.S. Shipbuilers undertake vast and expensive changes to their facilities, at least not until they have achieved all the improvements possible from people and process changes. In fact changes in facilities without the **required changes in people is simply throwing money and time away.**

A well-known management writer, (Pfeffer, 1994) has pointed out that if companies would spend a quarter of their capital expenditure on people who will operate the remaining three quarter investment in the new equipment, the return on investment would be many times greater than is currently achieved

This is not to say that U.S. shipbuilders can attain world competitiveness without changes to their facilities or by people changes alone. it is rather to show the primary role of people and to concentrate on that first. Then top management should let the empowered people decide what facility changes are required to reach the company goal.

Given that U.S. shipbuilding average wages are well below those of Japan and Europe, it would seem that the labor cost for a U.S. built commercial ship would be competitive. Unfortunately, it appears that this Labor rate advantage is overwhelmed by the significantly lower productivity rate for U.S. shipbuilders. The U.S. shipbuilding industry is not cost competitive. This is because the design, material requisitioning and construction all take more sort than the sucessful world class shipbuilders.

U.S. shipbuilders need to reduce their cost for commercial ships 30 to 50% How is this possible, especially when it is remembered that only 30 to 40% of the cost is directly controlled by the shipbuilder? Certainly the cost will be the man hours to design and build a commercial ship can be halved. But this would only reduce the COSt by 15 to 20 %. Obviously, the U.S. shipbuilder must attack the major cost and that is the material and equipment. U.S. shipbuilders must be able to obtain shipbuilding material and equipment on the world market at competitive prices. For too long the U.S. shipbuilding industry has been viewed as a "protected market" by foreign material and equipment suppliers and they have applied premiums to their prices. The U.S. must demand and get the best competitive price for its future commercial ships.

This is a "chicken and egg" situation. Cost reduction through improved productivity cannot be achieved until a sufficient steady throughput is available and this cannot be attained unless the U.S. shipbuilders are cost competitive. So, one way of

achieving this is for the U.S. government to develop the necessary commercial ship demand. There are many ways that this could be done and it is not the purpose of this paper to suggest any specific approach, but, rather to simply point out the need to provide the demand to get started on the road to improvement. Based on the discussion in the next section it would appear that the demand should be sufficient to give participating shipyards a minimum throughput of two ships per year. This would result in a 12 month build cycle.

Build Cycle

The only practical and profitable way to reduce ship build cycles is to increase the number of ships Wing built in a shipyard at a given time. The time from keel laying to delivery is directly related to the number of ships being built each year as well as the number of erection berths, and the time each ship takes on the erection berth.

Some Japanese shipyards deliver six ships per year from one building dock. Of course tandem building and large lift capacity are required to do this.

The build cycle (Start of Fabrication to Delivery) in months is given by:

$$\frac{12 \text{ X Number of Berths}}{\text{Number of Ships per Year X(Berth/Total) Time Ratio}}$$

Stating the obvious, for a shipyard, delivering one ship a year, it could take to a year to erect the ship on the berth. For two ships per year the berth time is obviously cut to 6 months.

One way to improve the build cycle is to reduce the time spent on the berth and this what the Japanese and better Europe shipyards have done to achieve their performance. The reduction in berth time may require longer time before Start of Fabrication in order to prepare engineering informantion, progress procurement, plan and production engineer the necessary work suitable for the shorter berth time. In fact, initially, the overall period from contract award to delivery may not actually be reduced but the berth, which is always the major constraint is used much more efficiently and hence the potential throughput of the shipyard is increased

It should be noted that world class shipbuilders are able to achieve shorter berth times while maintaining design and planning times which are much less than U.S. shipbuilders.

Consider the following

ORIGINAL BUILD CYCLE

Start of Fabrication to Keel Laying	4 months
Keel Laying to Launch(berth time)	6 months
Launch to Delivery	2 months
Total Build Cycle	12 months

Number of Ships per Year 2

IMPROVED BUILD CYCLE

Start of Fabrication to Keel Laying	5 months
Keel laying to Launch	4 months
Launch to Delivery	2 months
Total Build Cycle	11 months

Number of Ships per Year 3

The number of ships which can be output from the single berth is therefore increased from 2 to 3 per year.

Further assuming that the ship being built was a 40,000 TDWT Product Tanker. This would have a Compensated Gross Tonnage of about 18,000. and for a target productivity rate of 30 man hours per CGT and assuming 1830 man hours worked per year (average U.S.), a shipyard would require the following production manning:

1 Ship/year	295 employees
2 Ships/year	590 employees
3 Ships/year	885 employees

If a shipyard has 8,000 employees it will need to build many commercial ships each year, even highly complex types, to keep even half of them productively employed.

WHAT NEEDS TO BE DONE

The world class shipbuilding best practices are well documented. However, the extent of the documentation is overwhelming for individuals or small groups. Yet a broad revolutionary improvement is necessary for U.S. shipbuilders to achieve the desired goal of becoming competitive in the international commercial shipbuilding market.

The recommendations of a report on the U.S. "Search for World Class Manufacturing," (ward, 1993) can be adapted to U.S. shipbuilders as follows.

U.S. shipbuilders must first be willing and committed to learn and then act boldly. Understanding the U.S. shipbuilders relative performance by benchmarking against tangible

performance measures should create the imperative for change. Top management must:

- Find out how far behind world class they are. The result of benchmarking their performance may shock them into action.
- Use the resulting crisis to commit the shipyard to closing the performance gap through a shared vision of an integrated alignment of the business process, organization and technology with the business strategy.
- Recognize that the gap can only be closed by building the knowledge and skills of the employees, working together in teams and communicating.
- Determine customers requirements and exceed them.
- Create oppotunities to learn from world class customers or joint venture partners.
- Build shared destiny relationships with your suppliers.
- Eliminate customer non-value added tasks.
- Organize around process flows and not functions.

To this list the authors add that U.S. shipbuilders must:

- Reinstate industrial engineering techniques into shipyard operation to ensure correct analysis and application of new processes.
- Quickly learn how to cooperate and undertake pint ventures with other shipbuilders to develop the necessary significant and expensive technology research Even the largest U.S. shipbuilder working alone will not achieve the national goal of capturing a reasonable shine of the international commercial shipbuilding market.
- Marketing must become proactive rather than reactive. Successful foreign shipbuilders spend up to 2.5% of their annual sales on marketing.
- Concentrate on the many U.S. ship owners that build their ships abroad. Without a significant Change in this area it will be very mcuh to achieve the demand level necessary for the U.S. shipbuilders to attain short build cycles. This in turn will prevent them from achieving international commercial shipbuilding competitiveness.
- Form strategic alliances with ship owners, charterer suppliers, financial and trading houses in a similar way to the Japanese and even the German shipyards.
- Focus on specific ship types and sizes and not tru to be so flexible as to be able to build any ship type and size. The drive in flexibility in ship type in the small to medium European shipyards is believed to be the reason for their poor performance and lack of success. **European** shipbuilders that focus on specific ship types such as Meyer Vaerft in Germany, Odense Steel Shipyard in Denmark and the Finnish Ship shipbuilders have done relatively well.
- Atleast establish separate military and commercial divisions within their shipyards and after some success even separate shipyards. Shipbuilders throughout the world have shown that dual purpose shipyards cannot be internationally competitive for commercial ships. Even in Japan, dual purpose shiphards have productivity problems. U.S. dual purpose aircraft manufacturers learned this lesson along time ago.

It is suggested that what is required is an understanding of the 20 percent of the potential improvements that will result in 80 percent of the potential benefit from them all. Or to say it in a more American way, "what gives the biggest bang for the buck?"

Some of the 20 percent improvements are listed in Table XL

Table XI-20 Percent Best Practices

People — Potential Improvement 30 to 50 %

- Educate all managers in world class shipbuilding best practices
- Reward people for trying new ways
- Pay for improvement in productivity
- Change from mechanistic, no trust organization to organic, empowered people organization
- Break dowe departmemt barriers - use cross-functional teams
- Emphasize internal collaboration not competition
- Involve everyone to their full potential
- Educate and train everyone and_ a learning organization

Processes

Re-engineering — Potential improvement up to 500%

Other - — Potential Improvement! 10 to 25 %

- Keep them simple
- Reinstate industrial engineers and use their techniques
- Eliminate non-value added tasks
- Formally identify improvements in throughput
- Make analysis of processes away of life
- Establish stable processes
- Use Group Technology to categorize part families

and to reduce variety and automate process planning

- l Use Integrated Product Development
- l Use Build Strategy approach
- l Use a PWBS to integrate processes

Technology Potential Improvement 5 to 15%

- l only consider new technology that offers at least a 50% improvement over what it replaces
- l Make sure all additional costs are taken into account
- l Make use of proven technology such as CAD/CAM/CIM Integrated Product Development and Robotics that can bring about significant advantage

once the improvement approaches are decided each shipyard must develop a set of strategies to implement then It is here that re-engineering, IPD and people improvement approaches can be the road map and directions to successfully reaching the shipyard's goals.

An alternative to individual shipbuilder initiative is for U.S. shipbuilders to copy their most successful competitors and learn to cooperate in basic research Both Japan and Europe, but mostly Japan recognize that as individual shipbuilders they cannot develop the technology required for significant improvement. When national goals are identified, they readily cooperate and, with government assistance, set about achieving them. The eight year CIM project in Japan and the E3 Tanker development in Europe are examples of this approach

The Japanese Association of Shipbuilders plays a major role in this important activity by identifying the research required at the national level in accordance with a specific long term strategy. There is no such group that does this in the U.S. Even before the break up of the American Shiplbilders Council, it is doubtful if they could have fulfilled this role. It is suggested that the U.S. needs such a group and that one be established to direct the long term national shipbuilding research. It is further suggested that the NSRP could be grown into this role.

CONCLUSIONS

Competitiveness is much more than either cost or short delivery time considered as individual factors. It is an attractive combination of these and many other factors to the ship owner.

The major challenges for U.S. shipbuilders are how to operate large shipyard size and be competitive with world class shipbuilders, and how to successfully handle the dual purpose shipbuilding situation where the U.S. Navy will still be the major customer in regard to the use of facilities and resources. Others have tried to be dual purpose shipyards and have failed. Perhaps by a combination of re-engineering and American ingenuity U.S. shipbuilders can be successful in this quest

There are many known ways through which international competitiveness could be accomplished, and this paper has attempted to discuss some of them However, they are not a shopping list from which U.S. shipbuilders can select some and ignore the others. They are all part of a proven, integrated approach that is used by world Class Shipbuilders. Accuracy Control is the foundation PWBS is the lynch pin, stable Processes and variety reduction are the mode of operation, and the Build Strategy documents how they all will work together in a specific shipyard to suit its Business Plan and Shipbuilding Policy.

U.S. shipbuilding management must be willing to apply the new approaches to shipbuilding in organization, processes, and use of people to maximize the throughput of their facilities and then, and only then, should they consider investment in equipmert.

what remains? As NIKE says

"JUST DO lT!"

ACKNOWLEDGMENTS

The authors have used many sources for the data covered in this paper. They have attempted to indicate these sources where used. However, it is Possible that proper acknowledgment may be omitted If so, this was not intentional. In some cases the data was previously used in a number of publications and the authors referenced the source in which they found them.

The authors accept full responsibility for the way the data were used and for the inferences and conclusions deried therefrom.

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SiIver Bullets Shoot You Dead: -Planning for Integrating Technology, Organization and People Change

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Paper to be presented at the Society of Manufacturing Engineers
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Silver Bullets Shoot You Dead: Planning for Integrating Technology, Organization and People Change

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ABSTRACT

High failure rates for new technology result from inadequate planning for integrating technology change with organizational and people change. Characteristics of adequate integrative planning are described. Tools do not currently exist for providing immediate and detailed information about likely impacts of any change in technology, organization and people on other aspects of the organizational system. A new tool, Called ACTION, has recently been developed based on close collaboration of academia and industry. The tool is currently in pilot use in industry. A select industry experience with the tool is described.

HIGH FAILURE RATES OF NEW TECHNOLOGY

Accumulated evidence indicates that the implementation of computer-automated technology has not achieved as much success as originally antciapated (6). For example, the American Reduction and Inventory Control Society and the Organization for Industrial Research have estimated the failure rate of these technologies to be as high as 75% (14). In a study in

"This paper was prepared as a result of a program sponsored by the National Center for Manufacturing Sciences. This is a joint R&D program among industry and academia.

which 55 managers in 41 organizations supplying or using CAM were interviewed, half of the CAM initiations Were reported as failures. (3) In a 1990 SME-sponsored survey, 364 engineers recently purchasing or selling AMT were asked to evaluate their experiences (13). Only 49% reported that the AMT user expressed overall satisfaction with the transaction; 57% claimed disappointment with at least one of the following aspects of the transaction machine cycle time, reliability, WIP inventory, labor savings, flexibility, quality. As a final example, Fortune magazine estimated that GM put $77 billion into new plants and equipment to reduce labor costs. "Some robots it acquired in the mid-1980s stand unused today. The highly automated equipment never delivered the promised savings.” (11)

WHY THESE HIGH FAILURE RATES

Failures or problems with new technology can occur for a variety of reasons: technical barriers, inadequate skills, inadequate resources, etc. However, accumulated evidence indicates that the major source of problem is the inadequate planning for integrating the technology, people, and organizational change. In one of the first major studies on the problem of implementing new technology, the Congressional Office of Technology Assessment concluded: The main stumbling blocks in the near future for implementation of programmable automation technology are not technical, but rather are barriers of cost, organization of the factory, availability of appropriate skills, and social effects of the technologies (9); in short, inadequate integration. in a later survey by the Yankee Consulting Group, users of CAM and CIM reported that 75% of the difficulties they experienced with the technologies could be attributable to issues concerned with planning the use of the technology within the context of the organization (l). In an analysis of 68 applications for the Malcolm Baldrige National Quality award conducted by the American Productivity and Quality Center, a major reason for failing to meet the examination criteria was the neglect and failure to integrate human and organizational aspects with technology investments (4). The MIT Commission on Industrial Productivity concluded from their extensive examination of the competitiveness of different American industries: Reorganization and effective integration of human resources and changing technologies within “ companies is the principal driving force for future productivity growth (2). Finally, in a 1990 survey by Ernst & Young Consulting of top executives from 277 Midwestern manufacturing companies indicated that the success of technology is very dependent on a solid foundation of nontechnical characteristics concerning the business. These nontechnical characteristics included: people issues, flexibility, integrated planning, and clear priorities. (10)

In short, technology failures can be attributed to the inadequate integration of technical with social and organizational factors when change is introduced into the organization.

WHAT IS INTEGRATED IN INTEGRATIVE PLANNING

Figure 1 shows a high-level diagram of the range of elements in an organizational system that need to be considered in integrative planning. None of these elements is particularly new, in and of itself. Task dependencies refer to how work flows through the organization; skills and training refer to the capabilities of the workforce; technology refers to the type of technologies used and their characteristics such as reliability, human-machine interface, etc. In all, this list is illustrative for the breadth of issues to be considered when implementing new technology.

WHAT ARE THE CHARACTERISTIC OF INTEGRATIVE PLANNING

An integrative approach to planning for new technology differs in many ways from traditional non-integrative planning approaches. The first difference is the focus. In traditional approaches, the focus is on making explicit planning decisions exclusively about technical changes and leaving decisions about other elements in the organization to other functions, people, or implementation experiences. So, for example, manufacturing engineers focus on defining cell boundaries, programming software for process operations, or designing material handling layouts when new technology is being designed. Such a focus, however, ignores the reality that all elements of an organizational system are highly intertwined such that impacting one will, by fiat, affect others. Thus, by exclusively focusing on technical changes, critical other elements such as organizatioal and people issues are not explicitly designed. Since these elements of the organizational change wil1 adjust anyway, not explicitly deciding on what those changes should be leaves much change unanticipated. So, for example, ignoring the fact that people skills, reporting structures, and job descriptions will change - perhaps dramatically - with the implementation of new technology, means that skills, reporting structures and job descriptions will change anyway - just not in ways that have been explicitly planned.

Another way in which integrative planning differs from traditional non-integrative approaches is the belief that any change works because it is matched to all critical elements in the organization; in other words, there is no silver bullet. So, for example, a team approach that worked for Motorola's pager plant may or may not work for a different organization or a different site; JIT in Japan may or may not work for JIT in a U.S. electronics plant. FMSs may work for a particular machining operation

in one organization and may not work for what appears to be a very similar machining operations in another organization. By contrast, the traditional planner for new technology looks for the silver bullets; if it worked in Peoria, it must work here! Focusing on silver bullets (i.e., success stories in other companies) creates a false sense of confidence in the effectiveness of the process or program being described. What makes programs or processes effective is the match among the elements in the organization people adequately involved in the planning to share their ideas and gain ownership, task and job descriptions altered to accommodate the process change, skills were upgraded in preparation for new changes. Many of these changes are never discussed in presentation of success stories, leaving the audience to believe that the success can be solely attributed to the technology or process discussed.

A third way in which integrative planning differs from traditional non-integrative approaches is the effort to explicitly model and discuss interactive impacts of change on organizational and people issues. Reeingineering, an integrative planning process, suggests the explicit modeling of the workflow and mapping the workflow onto the reporting structure (5); sociotechnical systems analysis, another integrative planning process, suggests the detailed analysis of technical variances in the process and mapping these variances to how the people responsible for managing the variances do their work (12). In contrast, traditional, non-integrative planning approaches tend to be less systematic and rigorous in understanding impacts of technical changes on organizational and people issues. “Seat of the pants”, “incremental trial-and error”, and ‘intuitive, hands-on judgments” are the more frequently used analytical ”techniques of the traditional planner. In fact, it is not unusual for companies to ignore these issues until much later in the process, and then figure that everything will work out over time.

WHY IS INTEGRATIVE PLANNING SO DIFFICULT

One major reason why integrative planning is so difficult is that existing tools are inadequate (8). Simulation packages focus exclusively on technical design choices or very high-level human resource choices (such as workforce size or general composition). Business reengineering tools provide mechnisms for a user to build his or her own model of the organization; however, there is nothing to say that the model built is accurate; moreover, keeping the model updated as changes in technology, structure, and skills occur is difficult. Sociotechnical design tools are heavily resource-dependent and time-lagged, which makes the process of designing solutions slow.

Ideally, integrative planning wiIl be easier when a tool exists that contains a knowledgebase of how technical design decisions impact organizational and people issues (and visa versa). In addition, such an ideal tool would also be computer-based to allow for the simultaneous generation of alternative technology, people and organizational design decisions. Such a tool, under development for the last several years, is called ACTION.

WHAT IS ACTION

ACTION is a decision support system to help managers of business change analyze their current operations for adequacy of integration among technology, organization and people issues, as well as to identify new design choices. ACTION users may be change analysts in the organization such as industrial engineers, manufacturing engineers, or organizational change analysts. Alternatively, ACTION users may be managers, such as production managers, operations managers, or plant managers. ACTION is currently built for a discrete parts manufacturing operations, with expansion to other activities in an enterprise expected by 1995.

An ACTION user approaches the system from one of four vantage points, as illustrated in Figure 2. In the first vantage point, Strategic Visioning, the user is interested in determining the ideal organizational elements given a set of business objectives and production variances that s/he anticipates will exist in the organization of the future. The organizational elements included in ACTION are:

1) Business objectives
2) Process variances
3) Activities
4) Areas of discretionary authority
5) Reporting structure
6) Mechanisms for involving customers
7) Employee values
8) Performance management and reward characteristics
9) Reduction layout
10) Organizational norms
11) Technology system characteristics
12) Workforce skills
13) Production process characteristics
14) Information sources

The ACTION system contains a large knowledgebase of relationships between these elements. During the Strategic Visioning process, ACTION walks the user through a set of matrices describing these relationships, so that at the end of the session, the user can learn what the ideal organization should look like for any or all of the elements. In Strategic Visioning, the ideal organization is determined by seven business objectives. Ranging from reducing throughput or cycle times, to increasing product development responsiveness, the user can select any or all of the seven business objectives on which to focus.

A second vantage point for viewing ACTION is Strategic Assessment. A user interested in assessment describes his or her organization for each of the elements contained in ACTION. Then, ACTION indicates through color-coded output which characteristics (or constraints, in ACTION language) create the greatest problems for being able to achieve the business objectives identified by the user.

The third vantage point is a Detailed Organizational Asessment. In this use, the ACTION user inputs information about how 140 production related tasks are allocated in the current organization. In addition, detailed data is collected about 22 information sources, 30 skill types, 20 technology types, and 10 types of software programs. Having input all these data; the ACTION system then graphically presents a model of how all these factors interrelate, and the impact of these factors on the organization’s ability to achieve its business objectives. Part of an example model is provided in Figure 3.

The fourth vantage point is a Detailed Organizational Design, where the ACTION user inputs some constraints on the design, and the ACTION system computes the remaining unconstrained elements in the organizational system. So, for example, the ACTION user may constrain business objectives, the existing skills of the current workforce, and how tasks are assigned to jobs and then expect the ACTION system to identify which information sources and technologies are needed by which jobs, and detailed attributes of those information sources and technologies. Alternatively, the ACTION user may constrain business objectives and skills, but ask the system to generate a set of jobs by allocating tasks to different units.

The ACTION knowledgebase from which recommendations are derived was developed based on a series of metanalyses of the Literature (7) as well as intensive involvement of industry experts in organizational, people and technology change efforts. Participants from Texas instruments, Digital Equipment Corporation, Hewlett-Packard, and General Motors have been the main contributors. The ACTION system is implemented in Common Lisp, Garnet, and X-Windows, and comprises approximately 2MB of application source code. The software has been integrated and operational since February, 1993 and can run on Sun, DEC, or HP workstations.

In addition to the ACTION software and the knowledgebase embodied in it, the ACTION R&D program describes a methodology for user involvement and implementation of ACTION recommendations. Although still evolving, one finding of the methodology work has been the positive experiences gained by groups of people working with the ACTION system and seeing immediate feedback. By collecting the ACTION inputs in a group setting the individual identify and resolve differences of opinions that in the past festered as below-the-surface conflicts.

CASE EXPERIENCE WITH ACTION

Case runs with the ACTION system have been conducted by the industry partners to validate the knowledgebase and test the applicability of the knowledge and process in real world settings. Runs have been made on a wide variety of manufacturing contexts including electronics fabrication and assembly, automotive fabrication and assembly, and metal fabrication.

CASE BACKGROUND

The case described below was conducted in a metal fabrication facility which produces parts for the defense industry. The drastic reduction in defense expenditures has driven the company to down size their defense business bringing it in line with expected levels of defense spending. At the same time, this facility is struggling to become more competitive with other commercial fabrication shops that have lower overhead. These drivers are forcing the facility to make two major organizational changes. The first is a reshuffling of work load and equipment to move towards a Business Unit or cell-based production approach. At the same time, operators are being grouped into self-directed work teams with the role of supevisor transitioning to one of team facilitator.

At this point in the change process, facility managers have been relying on traditional methods for implementing the change. Individual issues have been addressed only as needed rather than planning ahead before problems arise. Training has been focused on communication and working in teams. Little emphasis has been placed on the effects to the larger organizational structure or broader people issues such as compensation systems. Internal efforts so far have supported the idea that organizational change is an extremely complex process with an overwhelming number of factors to consider. Silver bullets such as predetermined team structures, statistical process control, and cycle time reduction efforts have met with limited success. Understanding this, facility managers have supported the use of ACTION with focus on one business unit within the facility. The areas of improvement pointed out by the modeling, or Strategic Assessment, of the one unit can then be utilized by

the remaining business units at the facility. Without a tool like ACTION, the production areas would continue to use trial and error methods attacking specfic "fires" as they arise.

The unit modeled in this case is responsible for rapid reaction machining of low volume, medium tolerance, metal parts. The manufacturing process includes numerical control and manual machining, dri11, deburr, and inspection. The unit also has responsibility for developing their own process methods, numerical control programs, and scheduling.

The case has been developed by the site Industrial Engineer working with the Business Unit Manager. The Industrial Engineer was responsible for operating the system and consulting on the ACTION theory. The Business Unit Manager provided system inputs and worked interactively with the software.

CASE DETAIL

The ACTION case run begins with the identification of the business unit's, business objectives. In this example, the facility managers have selected the business unit's objectives to be:

- Minimizing throughput time
- Maximizing quality
- Maximizing employee flexibility for teams of generalists
- Maximizing manufacturability of designs
- Maximizing changeover responsiveness (reducing setup time)

These objectives are in direct support of the facility's need for competitive strength. ACTION first checks to make sure the unit's business objectives are in alignment with each other. It is critical that the area's individual objectives work together to achieve the area's total set of objectives. That is, different objectives are necessary to support the achievement of others. It is also critical that objectives be worked on the same level of scope. That is, if the unit is focusing on minimizing throughput time for a portion of the production process, then the ACTION theory would suggest that quality should also be focused on a portion of the production process.

In this example, no conflicts between business objectives was noted. Next, process variances are selected and aligned to the goals. In this unit, variances such as incoming quality, output quality, scheduling changes, and equipment reliability were identified as problems requiring considerable time and energy in rework, extra coordination, and equipment downtime. When these

variances were aligned to the unit's objectives, the Business Unit Manager could more clearly understanding the direct effect they had on the unit's objective of reduced throughput time and improved quality. The user then identifies additional organizational and human factors that the unit provides including: skills, information resources, customer involvement level, employee values, discretion technology and process characteristics, and performance measurement characteristics. In this case, the skill set is found in a group of skilled machinists, a ceil manufacturing engineer, and a cell production technician Their skill levels in their respective tasks are high but there has been little cross training to other tasks and skill areas. Most information resources are provided through computerized systems in the area. Information like customer needs and product costing are much harder to attain than those relative to the machining process. Direct customer involvement is extremely limited with direction regarding long-term scheduling, manufacturing improvements, and other issues coming from manufacturing management rather than customers. Employee values support continuous improvement and a learning environment. Discretion is primarily given regarding the manufacturing process. Workers do not exercise discretion over broader areas such as talking with customers and part redesign. Characteristics regarding the production process such as programmability, reliability, breakdown alternatives, and human over-ride are provided on the automated processes. However, a large portion of the unit's production is manual. The cell team facilitator currently evaluates each operator based on his/hers individual performance. Pay is based broadly on performance (quality) and on more general areas such as teamwork, attendance, and safety. Once these provided factors are input into the system, they are matched to the unit's goals and compared to what is needed to create a gap analiysis. It is this analysis that helps determine what additional elements are necessary for the unit to achieve its objectives.

SUMMARY OF CASE FINDINGS

The following are key analytical findings from this example. First, portions of the summary report pointed to the need for the business unit to have greater direct customer involvement. The unit had selected the goals of minimizing throughput time and maximizing quality. Each of these goals suggests a closer relationship to the customer in order to get the most out of each objective. Therefore, the ACTION theory suggests developing skills in understanding the customer's work processes, providing continuous information about the customer's needs, and directly involving the customer in issues such as long-term scheduling, evaluting the production area's performance, and developing new products.

A second key finding was focused on the unit's performance measurement and reward systems. In order for objectives to be achieved, a production area must know where they stand on the path to achieving their goals and feel that they will be appropriately rewarded. In this example, the ACTION run indicated that the business

unit needs to devote attention to providing compensation at a broader scope than just at the individual level. Performance measurerments and rewards need to include team and unit-based compensation. In addition, the standards need to be clearly communicated so that the entire unit can understand the connection between how they as individuals are being measured and the achievement of the unit's goals.

Finally, the analysis highlighted a need for greater involvement in redesigning and developing new parts. Traditionally, the facility as a whole has been isolated from the design community with new designs being "thrown over the wall" to manufacturing. In order to improve the manufacturability of designs, the unit needs to develop a stronger connection to project management and the design community.

RECOMMENDATIONS TO BUSINESS UNIT MANAGER

Based on the outputs from the ACTION run, several recommendations have been made to the Business Unit Manager. Two recommendations were focused on improving customer involvement. First, operator visits to the customer's work site were suggested. These visits would provide a better understanding of how the customer is using the business unit's product and allow the machinists to hear first hand about what is really important. One such visit has been conducted in the past and proved to be an outstanting learning opportunity for the operators as well as the customers. Continuing these visits on a regular basis is recommended. A second proposal to improve customer involvement was to feed the details of the customer survey results down to the business units. Typically, these results are reviewed by the planning organization and not shared with the areas directly responsible for the product.

Evacuating the system outputs relative to performance measurement yielded two recommended improvements. The first is to implement a team-based review process. The cell teams in this unit are now advanced enough to take advantage of this method of review. Secondly, the unit should focus on the key business objectives of the organization, posting the specific numeric goals so that all can see where they are and where they need to go. Most importantly, they need to be judged on their achievement of these goals.

Finally, to create tighter links to the design community, the unit has begun dealing directly with project management and the design engineers on issues such as manufacturability and production cost estimating. This link needs continued strengthening in the future to allow continuous communication rather than just in a few special cases.

In summary, the ACITON recommendations have been reviewed by the Business Unit Manager, with a more speafic implementation plan under development.

CONCLUSIONS ABOUT ACTION USE

Several conclusions can be drawn concerning the ACTION process. The Industrial Engineer working with the Business Unit Manager may have limited the knowledge scope, not providing as complete or as accurate a picture of the current operations. In future applications, it is recommended that ACTION inputs be gathered from a broader base of individuals involved. Talk with the operators, cell engineers, and customers. Often times it is these frank and open discussions that create the greatest insight to the production area. Secondly, we found the interactive nature of the system to be very valuable. The impact of the technology, organization, and people trade-offs were more clearly understood by mamagement when they could see immediate response to their changes in inputs. The implications to the business objectives meant more coming from an "expert system" supported by an engineer rather than from an engineer alone. It is noted however, that at this time, the system needs an "expert" user in order to facilitate its use and translate its output. It is" expected that in further phases of this work the system will become more user-friendly for the "novice" user. Overall, the recommendations and insights provided by the ACTION process could be considered common sense. What is important is the interactive ability to balance ALL of the technology, organization, and people issues against each other. During the typical change process, it would be difficult to consider all of these factors to come up with a complete and comprehensive solution. In this example, the Business Unit Manager was not particularly surprised by the results, everything seemed to make sense. He did however, realize that many of the important issues would have slipped through the cracks without the help of a defined theory, methodology, and automated system. Without ACTION, he would have counted on the "silver bullet" of teaming and business unit alignment alone to solve everything. Now the bigger picture is understood and corrective action can begin.

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Figure 1. Action Open Systems Model

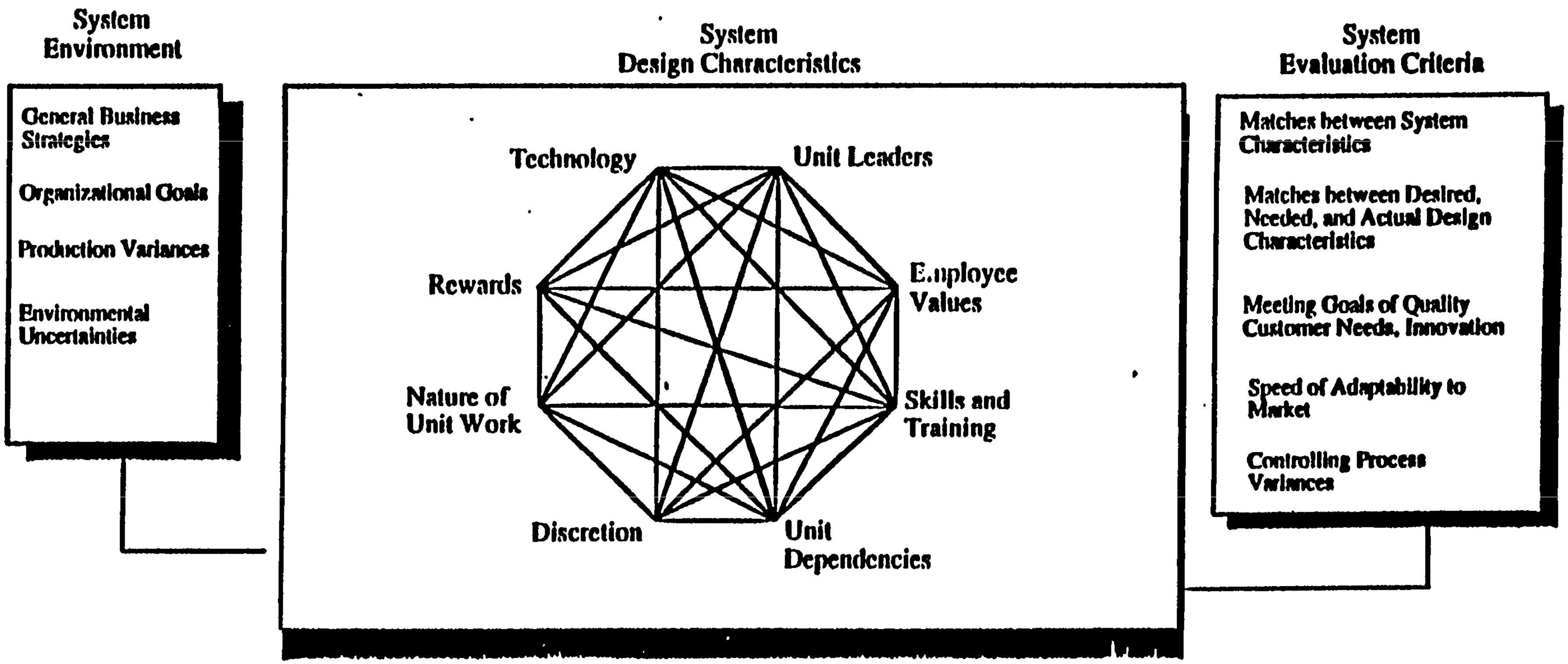

Figure 2

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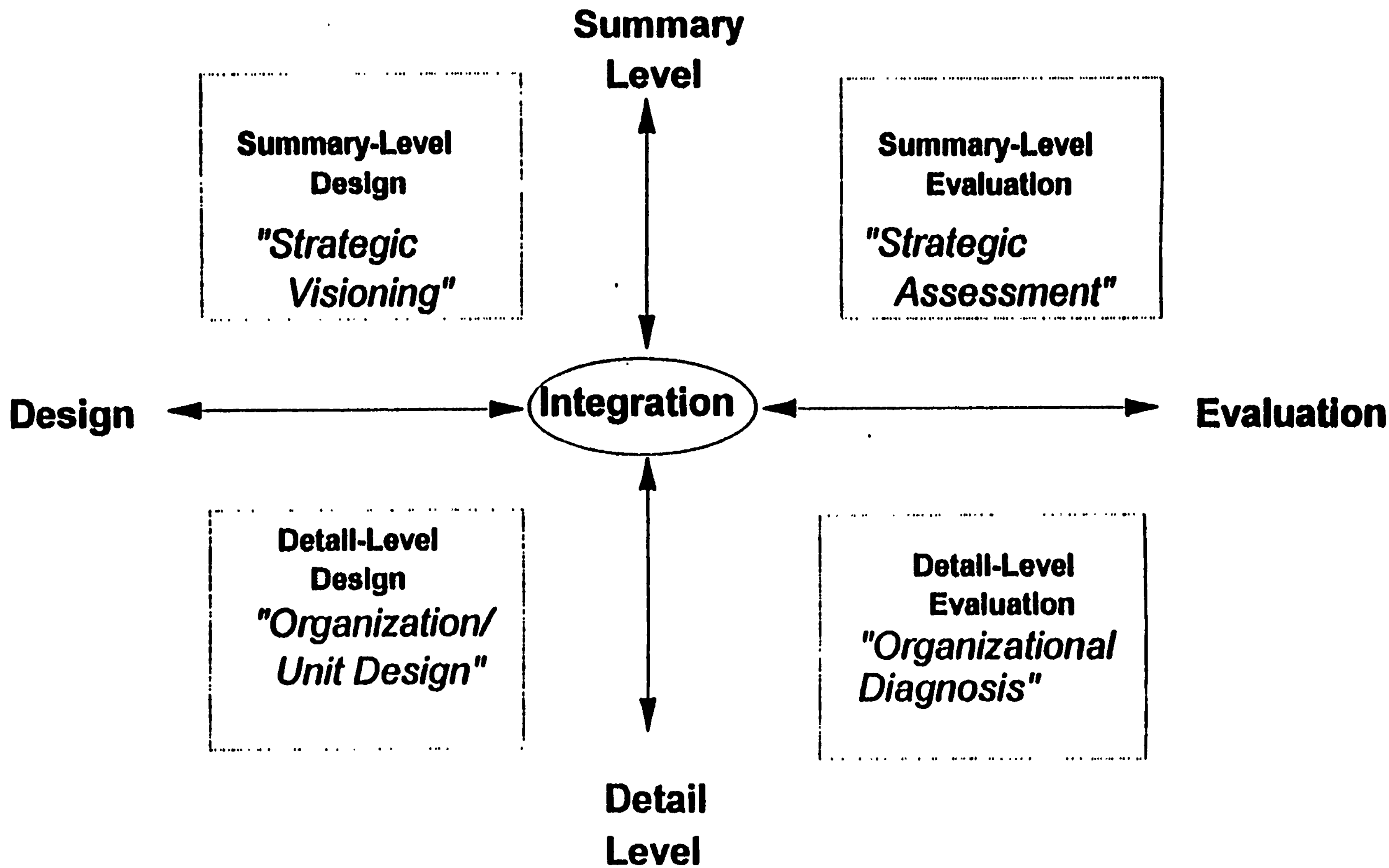
ACTION Methodological Framework



HEWLETT PACKARD

Figure 3

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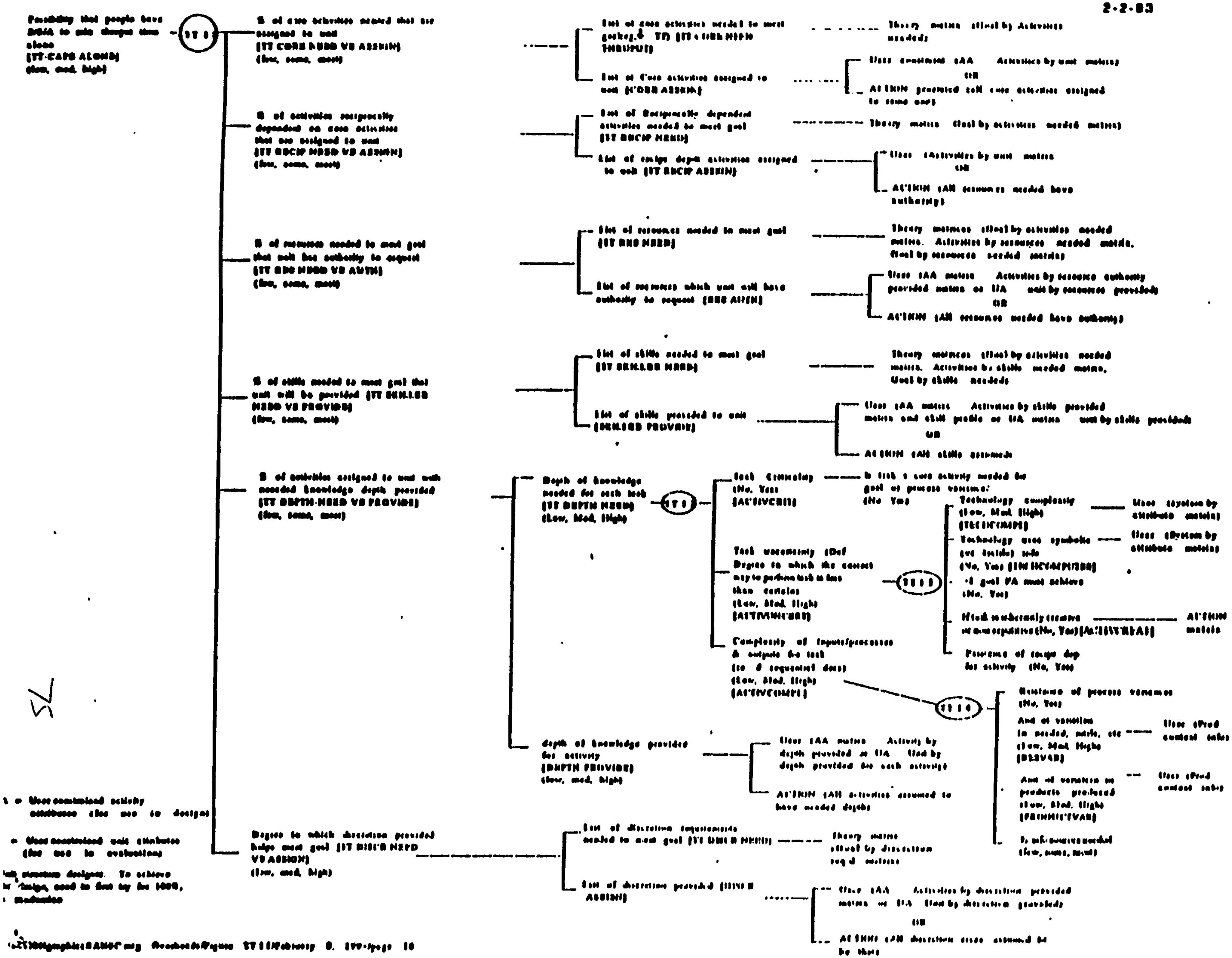

The World-Class Company

Describing a company as world class means a number of things. It means the company has achieved high standards of business performance and has undergone fundamental changes in the way it's managed. But above all, it's profitably meeting the needs of customers while continuously improving its ability to do so.

Success in the world-class company is measured in the eyes of the customer. The goal is not simply to satisfy customers, but to positively delight them. The Japanese call it miryokuteki hinshitsu-designing products that are not only reliable and cheap to make, but also fascinating and delightful to the customer.

What delights a customer?

The specifics vary from industry to industry, and from product to product. But most customers want the same basic things:

- Cusotmers are interested in quality-they want their purchase to work to do the things they want it to, and to please them in the process,
- They desire good service-they want their products and services delivered on time.
- They want fexibility-they want the ability to obtain the specific product or service they want.
- They covet value-they don't want to pay a price that exceeds the value received from the product.

Delighting customers is not something you do once and then rest on your laurels. With hungry competitors breathing down its neck, the world-class company continuously improves its ability to delight customers.

Everyone is committed to improving continuously in a world-class company. Often the individual improvements are small, Japanese companies such as Toyota are famous for "improvement by inches," But small improvements, if done year after year, grow in measure to provide an insurmountable lead.

What do world-class companies improve?

They improve the things that mattfer to their customers-quality, service, flexibility and cost. And they do it differently than other companies that haven't yet started on the path to world-class competitiveness. These differences permeate every function in the company,

For example, world-class companies design and build in quality the fust time. They don't have teams of inspectors looking for defects. There aren't any rework departments fixing faulty products. Instead, everyone in a world-class company is responsible for the quality of their own work.

Moreover, world-class companies make only what the customer needs. And they do it in a continuous flow. Parts are purchased or built just-in-tinte for the next process. Gone are the large batches of yesteryear-the goal is a lot size of one. Gone are the large buffer stocks of parts piled next to every machine or assembly station. Gone is the end-of-month scramble to meet sales goals-a scramble that increases cost and reduces quality.

products in a world-class company are designed by teams from engineering, production, marketing, and procurement. Gone are the days when designers "tossed a product design over the transom" and challenged manufacturing to produce it, Tools such as as quality function deployment (QFD) ensure that customer desires are reflected in the product design.

It's people who make the biggest difference in world-class companies. Employee involvement-pushing decision making responsibility down to the lowest levels of the organization-energizes the talents of everyone.

The result is a flat organization structure that facilitates cross-functional communication. This eliminates layers of bureaucracy (or what some people call "hardening of the categories" or "functional silos").

The activities of the world-class company are linked to form what Dick Schonberger calls a chain of customers. Each activity in the company has a customer-the next activity in the process. Each activity is dedicated to serving its customer. This forms a chain that ends with the paying Customer.[1]

NATIONAL SHIPBUILDING RESEARCH PROGRAM

THE

CANDY

STORE

IMPLEMENTING ADVANCED TECHNOLOGY

TOTAL QUALITY MANAGEMENT (TQM)

- **TQM IS A WAY TO GET ALL EMPLOYEES FOCUSED ON THE REQUIREMENTS OF THE CUSTOMER**

- **BASIC CONCEPT IS THAT THROUGH TQM IT IS POSSIBLE TO ACHIEVE DEFECT FREE PRODUCTS MOST OF THE TIME**

- **TQM ENSURES CUSTOMER SATISFACTION BY INVOLVING ALL EMPLOYEES DEVELOPING IMPROVED PROCESSES WITHIN A COMPANY TO CONSISTENTLY PRODUCE AND DELIVER PRODUCTS THAT MEET OR EXCEED THE CUSTOMERS QUALITY EXPECTATIONS**

TQM (Continued)

- CONVENTIONAL U.S. MANAGEMENT HAS BECOME A SIMPLE **SUM OF THE PARTS**

- TQM OBJECTIVE IS TO MAKE THE WHOLE GREATER THAN THE **SUM OF THE PARTS**

TQM (Continued)

- CONVENTIONAL MANAGEMENT EMPHASIZES

PLANNING

ORGANIZING

STAFFING

DIRECTING

CONTROLLING

CURRENT BEST MANAGEMENT PRACTICE EMPHASIZES

PEOPLE ORIENTATION

TRUST

TEAMWORK

OPENNESS

EMPOWERMENT

TQM - EMPLOYEE BENEFITS

- JOB ENRICHMENT
- INCREASED) JOB SATISFACTION
- INCREASED TRUST
- DEVELOPMENT OF TEAM SKILLS
- **ENCOURAGES INNOVATION**

TQM - COMPANY BENEFITS

- IMPROVED CUSTOMER RELATIONS
- FORCES DECISION MAKING DOWN TO APPROPRIATE LEVEL
- IMPROVED COMMUNICATIONS
- INCREASED TRUST RESULTS IN BETTER WORK RELATIONSHIP AND ACCEPTANCE OF NEW IDEAS/CHANGES
- IMPROVED PERFORMANCE FROM TEAMWORK
- IMPROVED EFFECTIVENESS
- REDUCED COSTS
- REDUCED ERRORS AND REWORK

TQM COMPONENTS

- MISSION AND VISION
- VOICE OF THE CUSTOMER
- VOICE OF THE BUSINESS
- CORE COMPETENCIES
- IMPLEMENTATION OF TQM PLANS

VOICE OF THE BUSINESS

- THE VOICE OF THE BUSINESS DETERMINES THE CONSTRAINTS AND OPPORTUNITIES WITHIN WHICH THE COMPANY OPERATES

- EXTERNAL

ENVIRONMENTAL
TECHNOLOGICAL
DEMOGRAPHIC
CREDITORS

ECONOMIC
SOCIAL/CULTURAL
LEGAL/REGULATORY

FINANCIAL
POLITICAL
SUPPLIERS

- INTERNAL

EMPLOYEES
DEPARTMENTS

MANAGERS

SHAREHOLDERS

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CORE COMPETENCIES

- **THE FOUNDATIONS OF COMPETITIVENESS**

- **THE COLLECTIVE CAPABILITIES THAT A COMPANY SHOULD DEVELOP AND MAINTAIN TO ENABLE IT TO COORDINATE DIVERSE PRODUCTION SKILLS AND INTEGRATE MULTIPLE TECHNOLOGIES**

- **ANALYSIS OF A COMPANY'S CORE COMPETENCIES PROVIDES AN INDICATION OF HOW THEY ARE ALIGNED WITH THE COMPANY'S BUSINESS PLAN AND STRATEGIC OBJECTIVES**

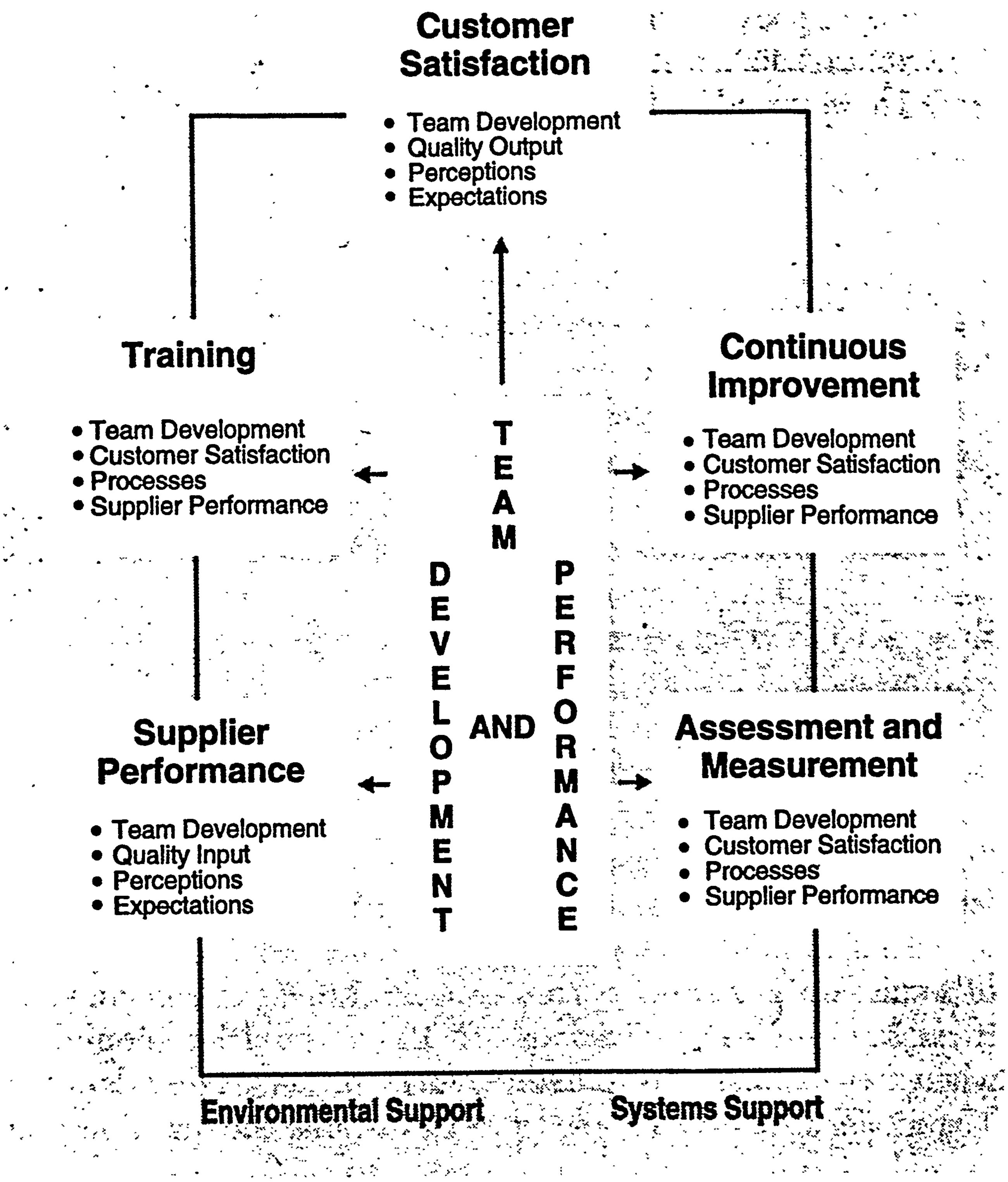


Figure I-1. Team-Centered Total Quality Management

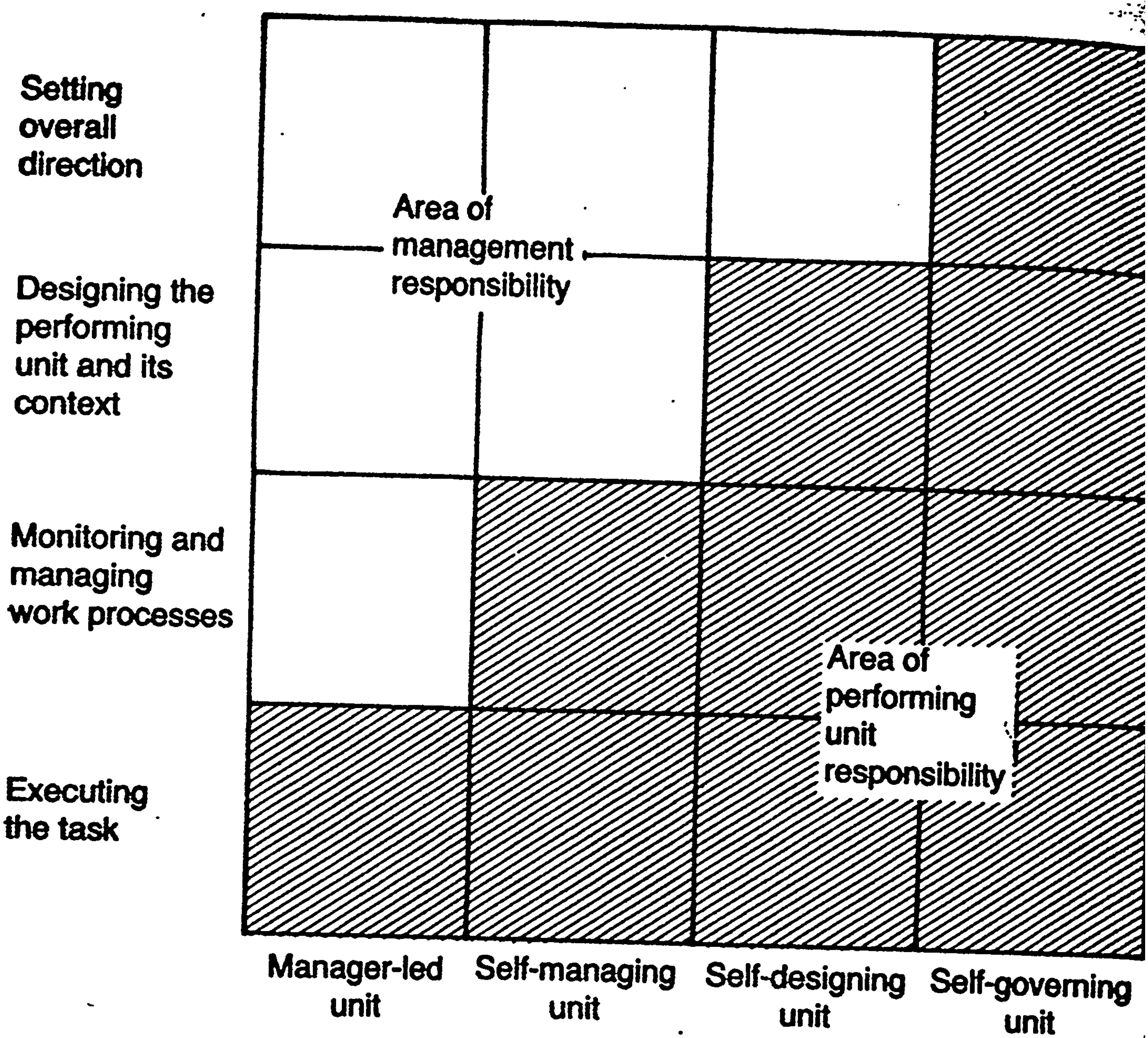
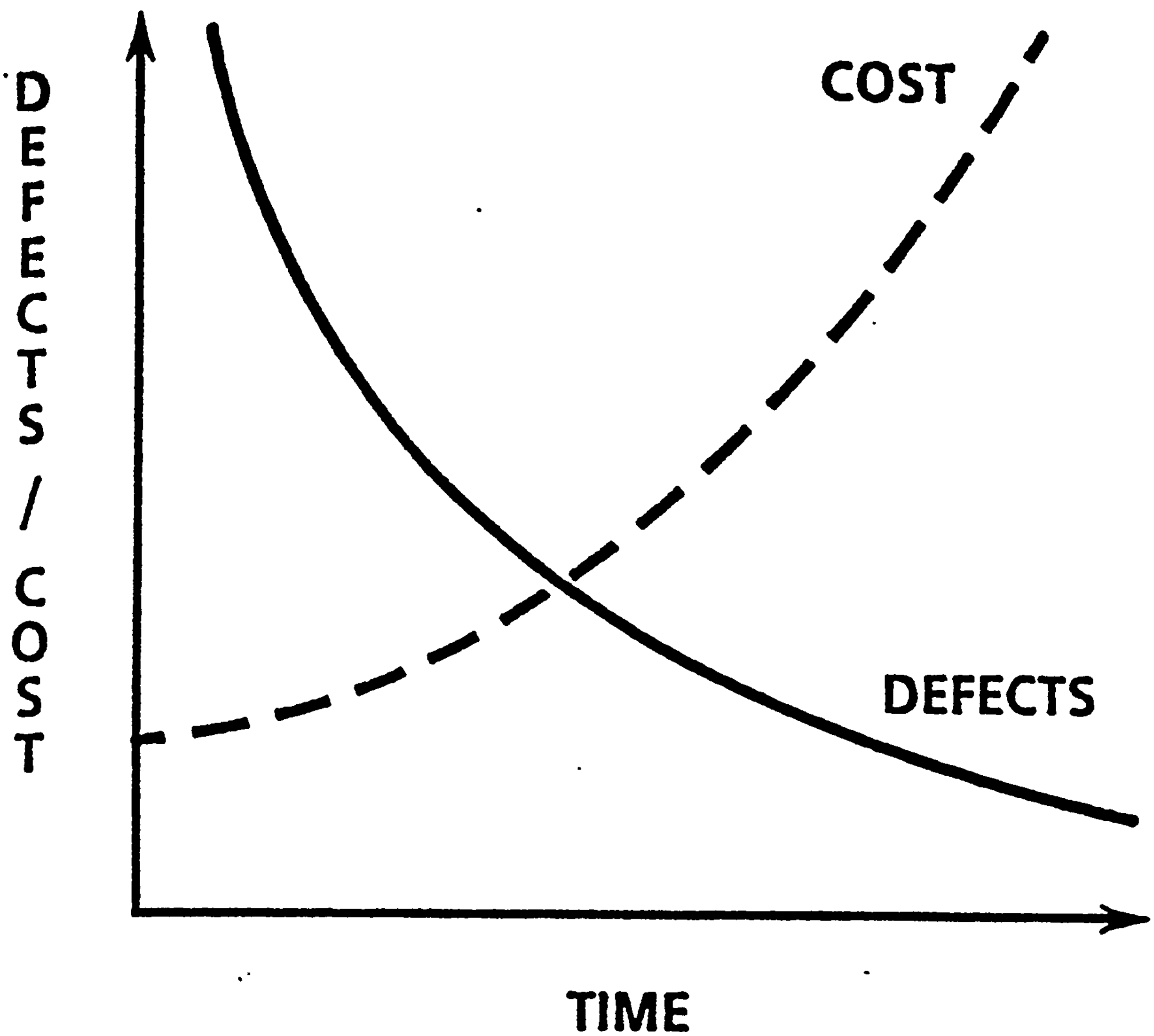
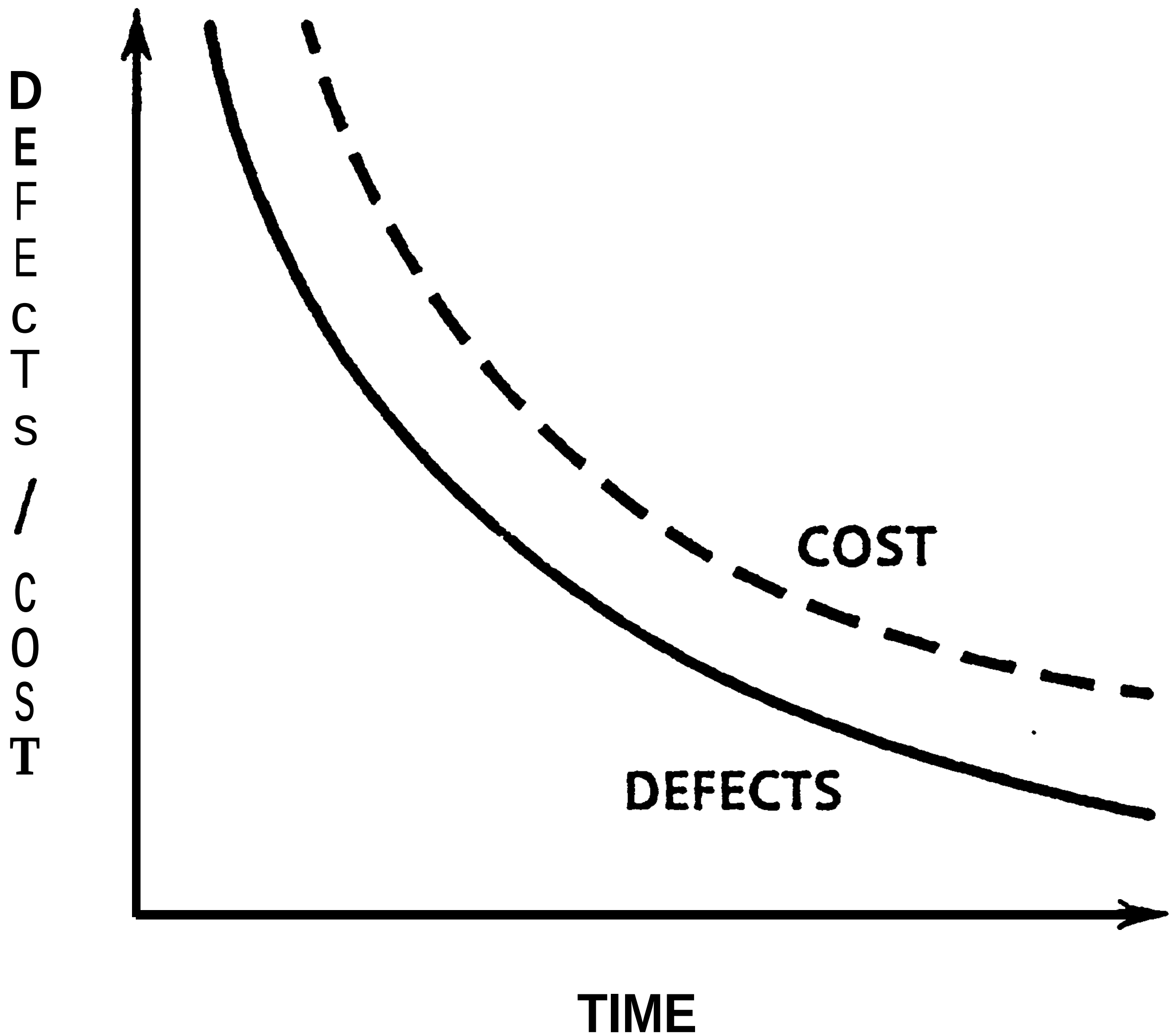


Figure 2.10 Hackman's authority matrix: four characteristic types performing units.

Core concepts of TQM



The Essence of Total Quality Management



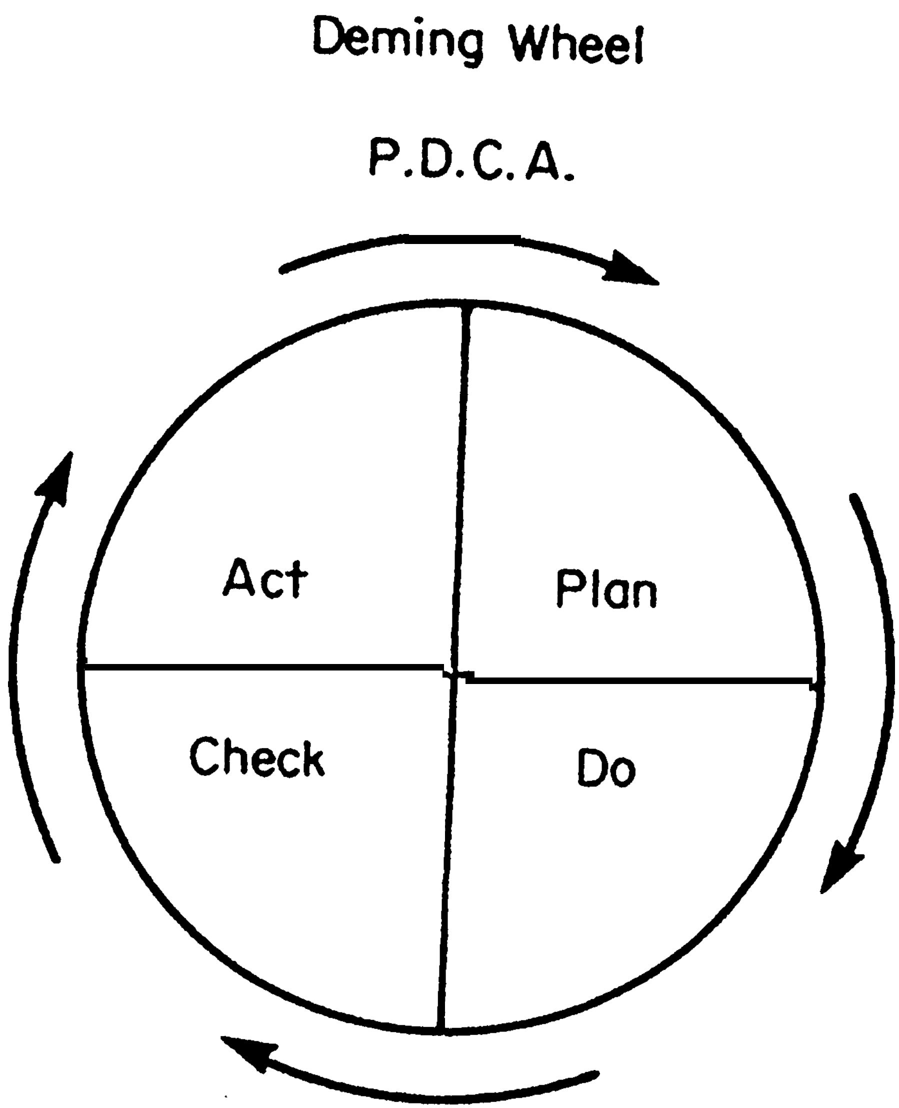
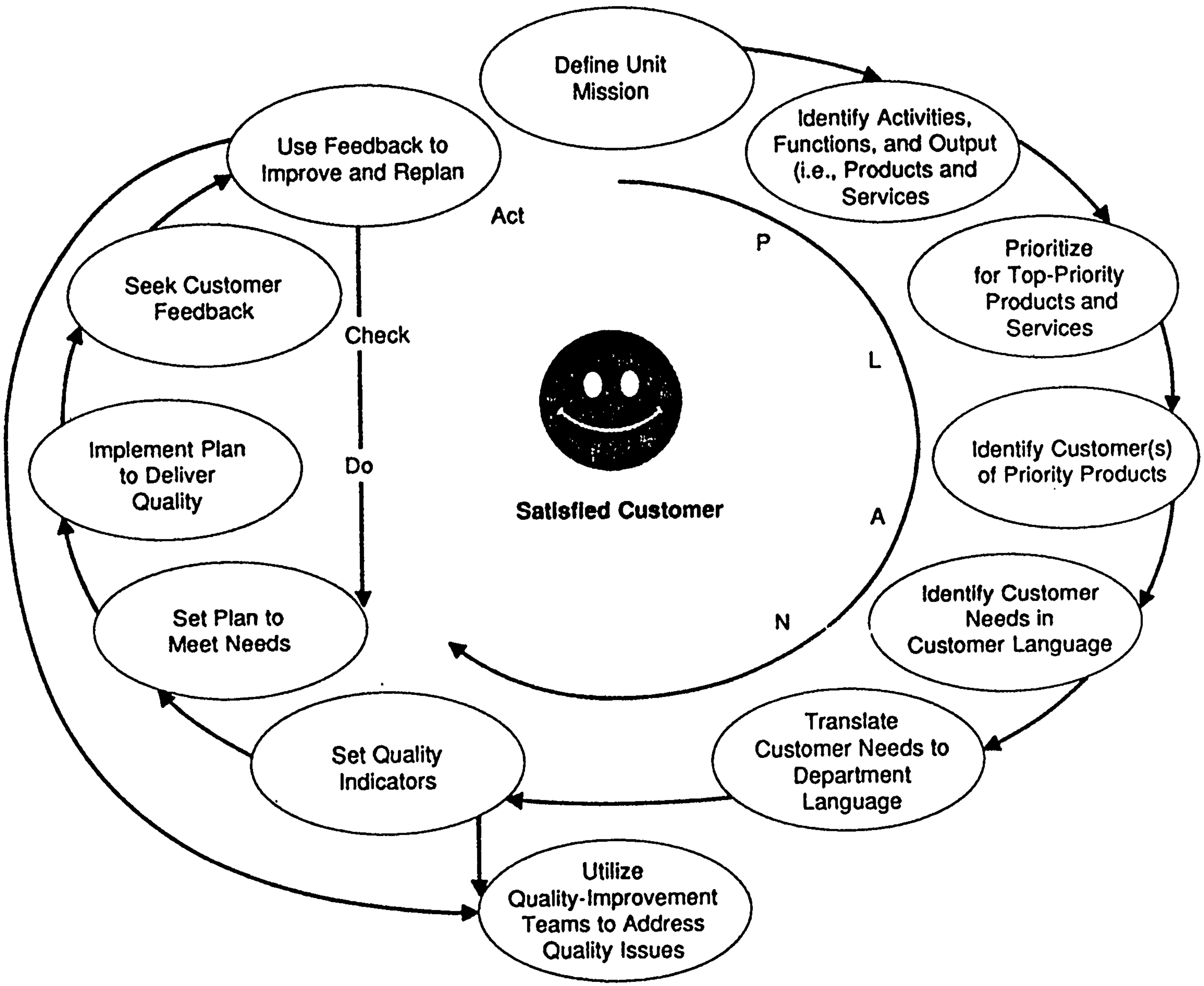


Figure 4-3. Deming Wheel.


Define Unit Mission
Identify Activities, Functions, and Output (i.e., Products and Services
Prioritize for Top-Priority Products and Services
Identify Customer(s) of Priority Products
Identify Customer Needs in Customer Language
Translate Customer Needs to Department Language
Set Quality Indicators
Utilize Quality-Improvement Teams to Address Quality Issues
Set Plan to Meet Needs
Implement Plan to Deliver Quality
Seek Customer Feedback
Use Feedback to Improve and Replan
Act
Check
Do
P
L
A
N
Satisfied Customer

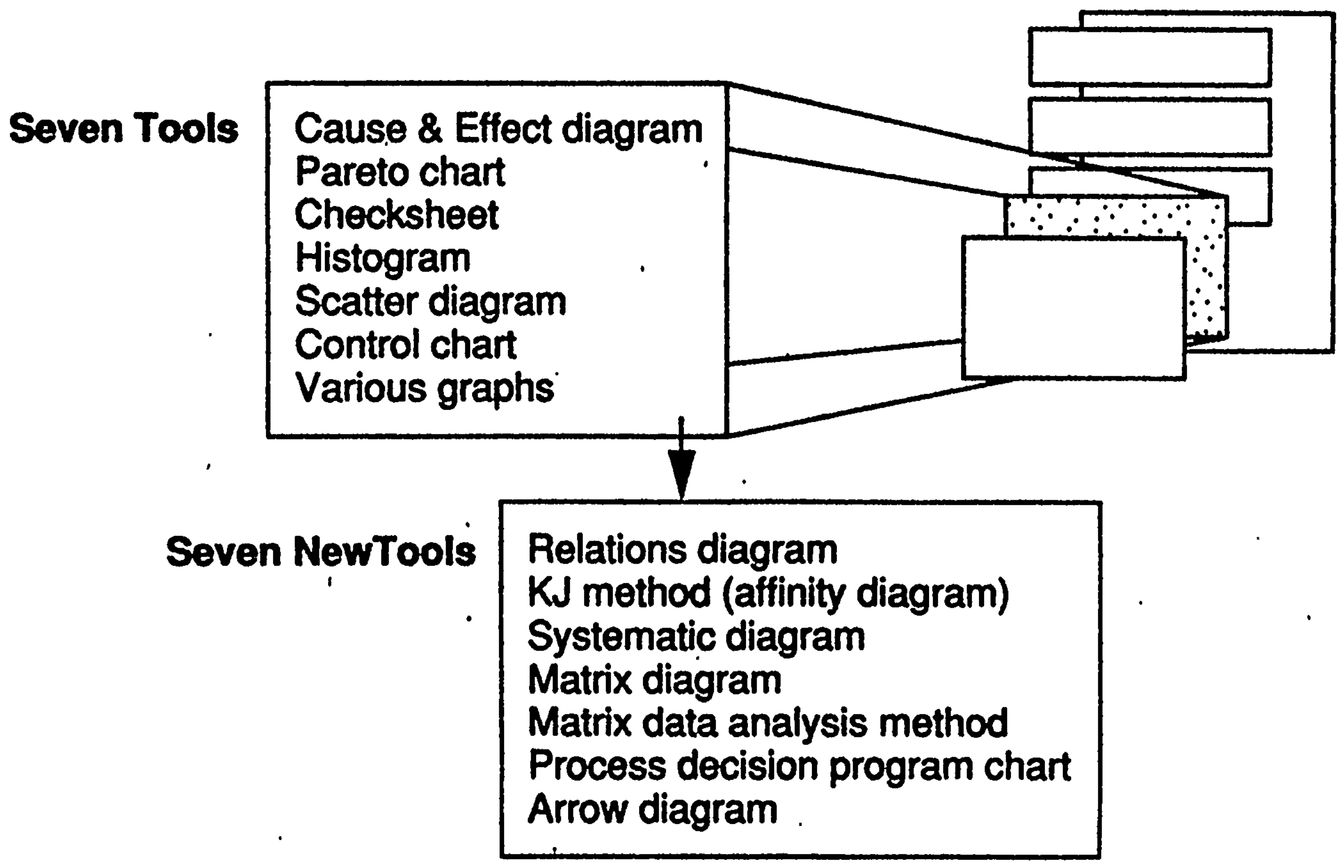
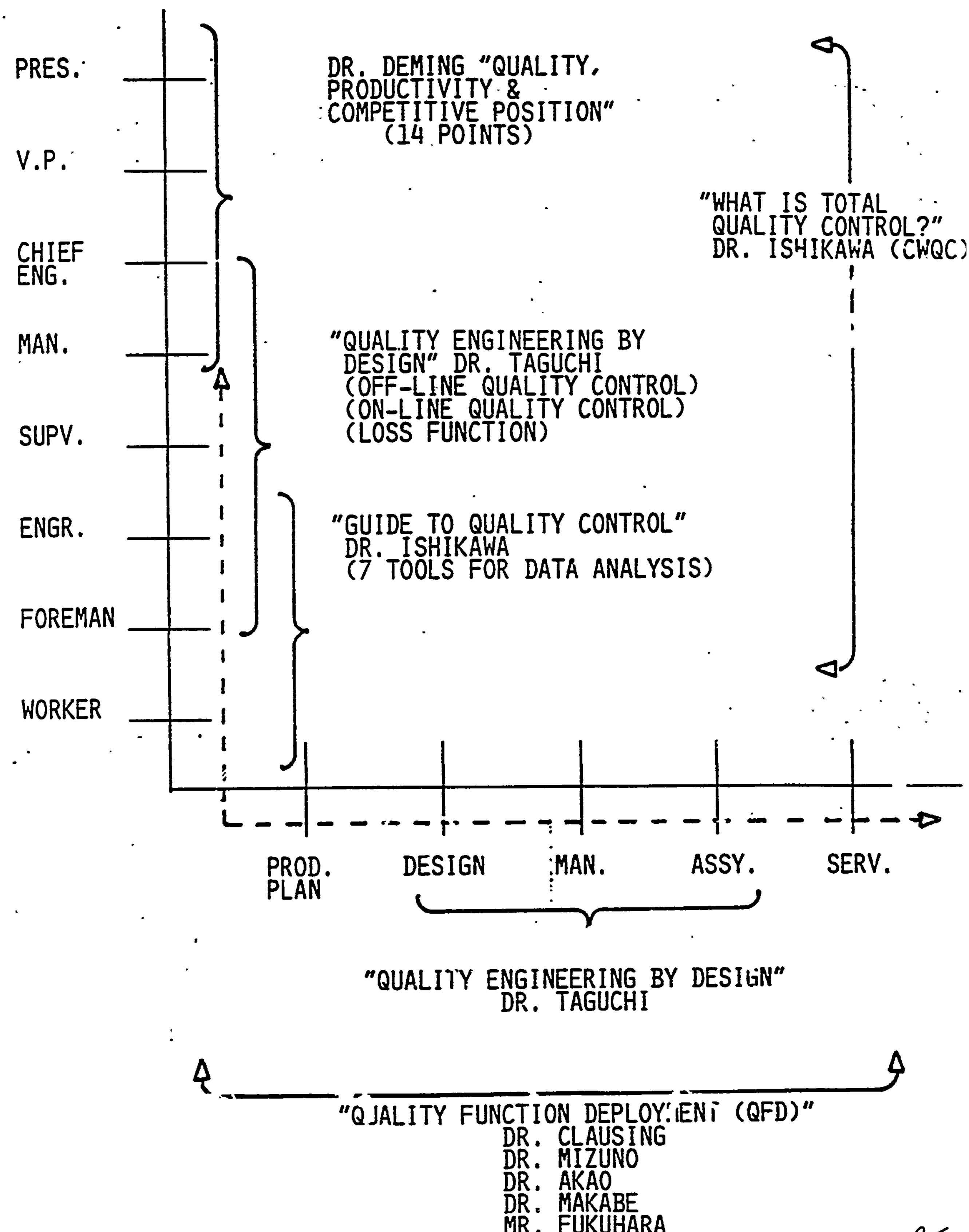
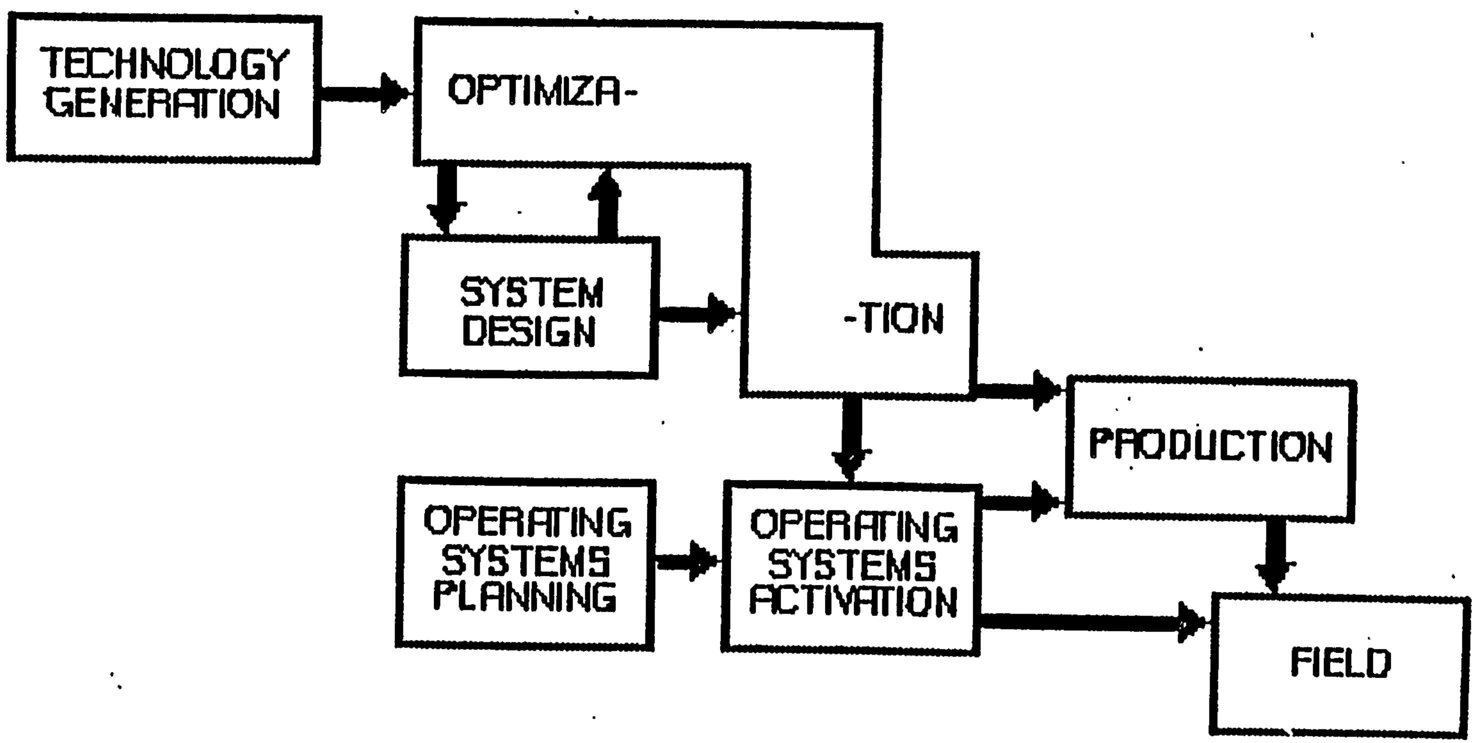


Figure 6-4 The Seven Old Tools and the Seven New Tools

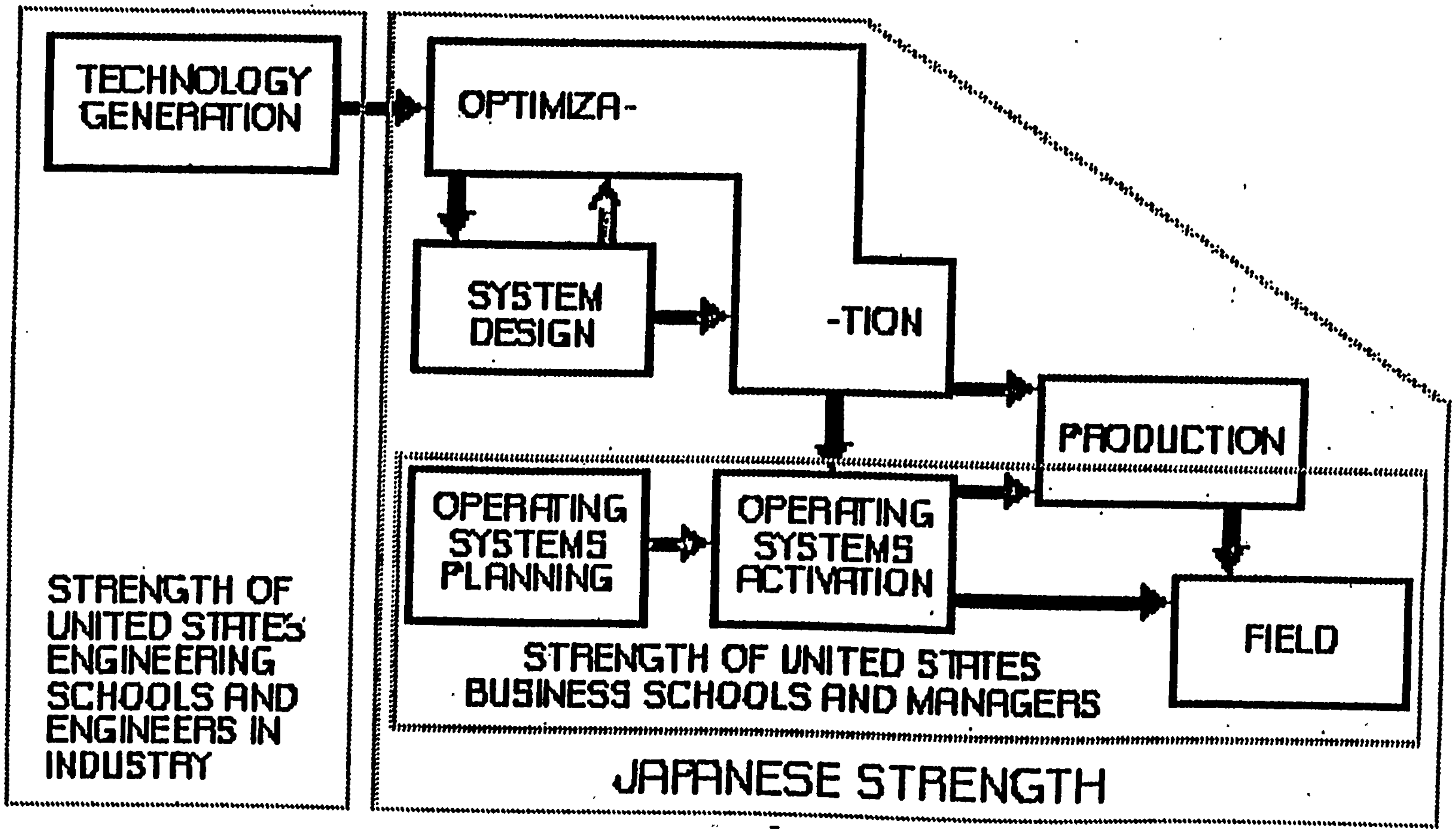
MATRIX OF NEW QUALITY TECHNOLOGY



TOTAL DEVELOPMENT PROCESS



PRESENT STRENGTHS IN TOTAL DEVELOPMENT PROCESS



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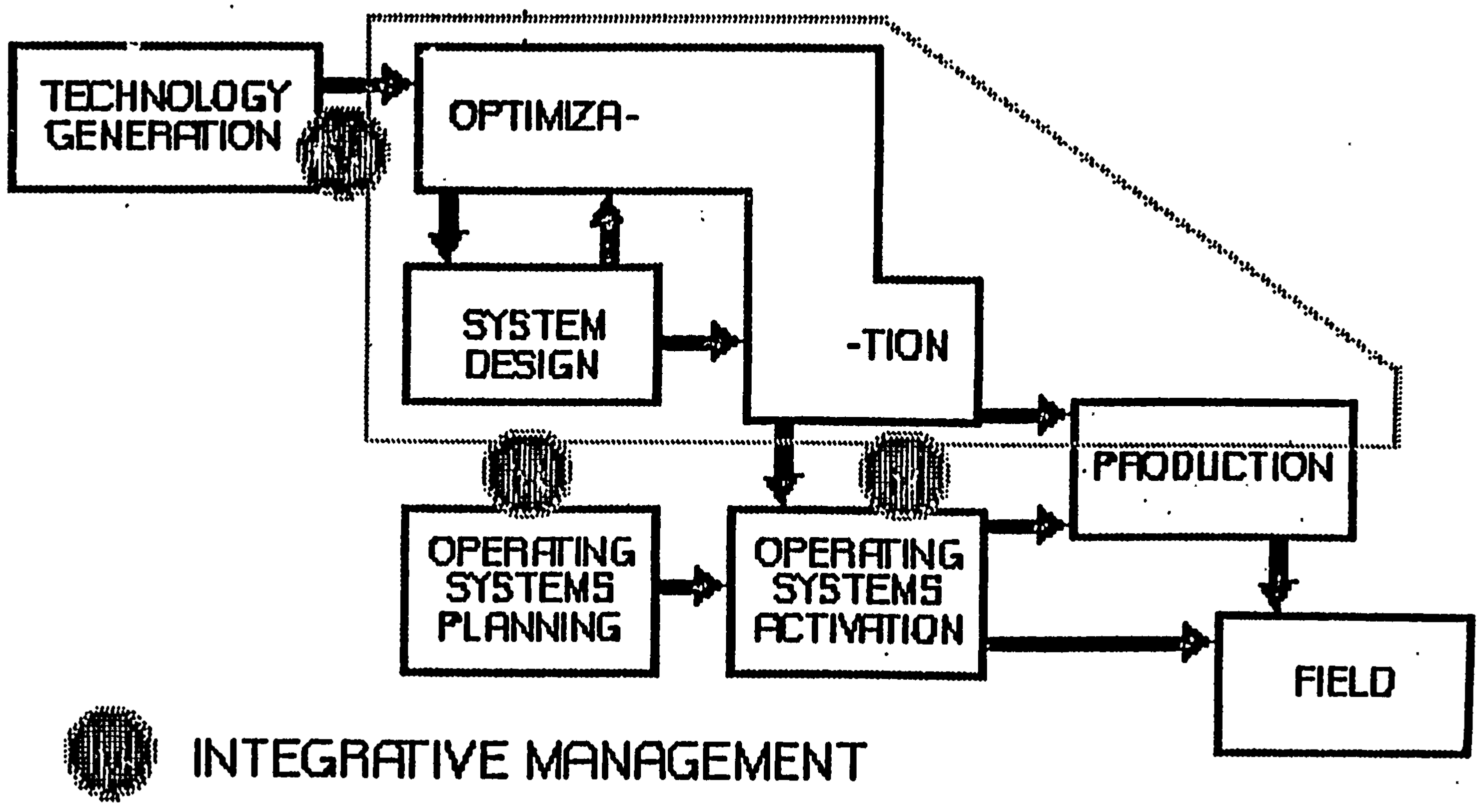
97
5

(1)

REQUIRED NEW UNITED STATES STRENGTHS



SEAMLESS ENTERPRISES

SEAMLESS ENTERPRISES USE CROSS-FUNCTION MANAGEMENT AND CONTINUOUS LEARNING TO ENABLE TQM TO BE SUCCESSFUL

CROSS-FUNCTION MANAGEMENT IS NOT THE SAME AS CROSS-FUNCTIONAL TEAMS ALTHOUGH C-F TEAMS CAN BE MANAGED BY IT

WITHOUT CAREFUL MANAGEMENT, CROSS-FUNCTIONAL TEAMS CAN REPLACE FUNCTIONAL STOVEPIPES WITH CROSS-FUNCTIONAL STOVEPIPES

SEAMLESS ENTERPRISES (Continued)

CROSS-FUNCTION MANAGEMENT IS WOVEN THROUGH THE VERTICAL FABRIC OF A COMPANY'S ORGANIZATION STRUCTURE WITH COMPANY WIDE HORIZONTAL AUTHORITY

CROSS-FUNCTION MANAGEMENT IS NOT AN ADAPTATION OF THE "TWO BOSS" MATRIX MANAGEMENT

SEAMLESS ENTERPRISES DELIBERATELY BUILD A STRUCTURE AND A PROCESS THAT ENABLES HORIZONTAL COMMUNICATIONS ACROSS THE COMPANY. THIS EMPHASIS ON "LATERAL COMMUNICATION" IS THE CORE TO WHAT MAKES A COMPANY "SEAMLESS"

8: FOUR-FIELDS MAPPING

Product development is very easy. But we have made it very hard for cultural reasons. It should be one system, one team, one set of decisions.*[1] *Don Clausing (MIT)

Four-fields mapping is one of the most elegant and productive techniques used by cross-function teams. It allows the members to determine in advance not only who does *what* and *when*, but also the flow of information, or *who needs to know what when.* This collaboration is a critical feature of a cross-function process. From the start, it forces team members to specify how they will identify and communicate customer requirements systematically both *across* vertical departments and suppliers.

Cross-function process mapping does not resemble any of the common *who-what-when* techniques such as time-driven GANTT schedules, work-breakdown structures (WBS), or PERT charts. All these tools, while they are useful for narrowly prescribed reasons, fall short in one significant way. None of these tools depicts horizontal relationships or the sharing of information essential to making companywide teaming work. This works against concur-

rency; the tools encourage compartmentalization of tasks and, in turn, sequential management. Anyone who has drawn a GANTT chart will quickly recognize this. It is only illusory that a total process can be managed through the financial or scheduling control of single activities. In reality there is little disciplined man. agement going on because events are rarely linked other than through designated hand-offs. The tools perpetuate chimneylike task management.

The cross-function process map (see Figure 8-1) integrates four "information" fields:

1. The value-adding **team members** from all involved vertical chimneys
2. The breaking down of an activity into logical **phases;** clearly specified entry and exit criteria marking beginning and end points of each phase
3. Tasks to be performed and events such as decisions are **work flow** with special effort to depict horizontal concurrency and information sharing between team members at given points in time
4. Clearly delineated guidelines, regulations, or **standards** that are uniformly applied by all team members to activities and events

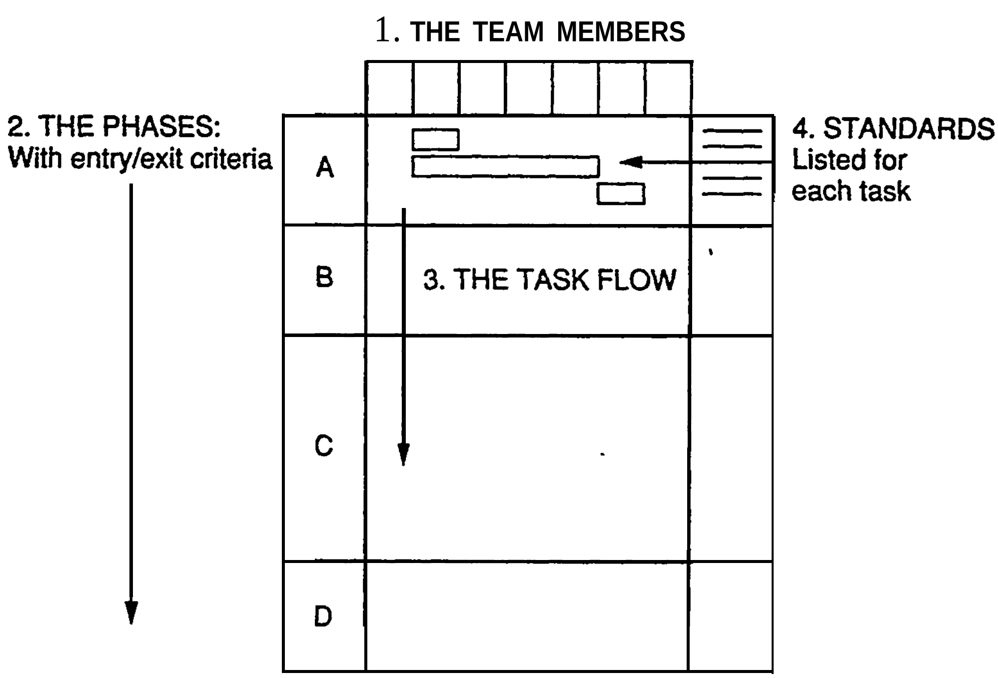


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Figure 8-1 Four-fields map

The creation of a four-fields map is a unique and distinguishing feature of cross-function management, one the author first encountered at Komatsu. *The making of these maps* ***helps stimulate the lateral communication that is widely acknowledged as a major shortcoming*** *of* ***conventionally managed companies.*** Generic four-fields "maps" are created by a corporate knowledge team to control quality, cost, or product development processes; these are used as blueprints from which working teams can customize actual day-to-day implementation programs.

Four-fields maps are useful as a management resource but also as an organizational learning tool. As **each** map captures the learning of a prior effort, it becomes the departure point for the next effort. This contributes to a continuous–improvement process in a format that is easily communicable and transferable among teams.

A four-fields map depicts the process necessary to achieve a particular end result. Like a highway map that depicts the general interstate system and also has the blowup of a street layout in a city, a four-fields map is hierarchical in its detail. It shows a whole process at the highest level of generality and also windows into detailed elements. A well-managed company will eventually develop a book of corporate process maps, each one describing process methods, procedures, experiences, and relevant testing techniques.

Constructing a four-fields map may be the most creative communication exercise carried out by a companywide cross-function team. Just the act of taking together, which is done surprisingly little across chimney boundaries, is a revelation. "It is not unusual for the relationship between Design and Manufacturing personnel to be somewhat adversarial," says Larry smith of Ford Motor Company. "Not long ago a Design Engineer (at Ford) stated 'Most product problems are a result of too much manufacturing variation.' A typical Manufacturing response, 'The Design is not robust.' It is an interesting exercise to ask Manufacturing and Design Engineers to identify the significant key characteristics of their product. On one particular occasion the two groups came up with totally differen lists: one group not aware of why the other considered the lis

RE-ENGINEERING

- *"RE-ENGINEERING IS THE RADICAL REDESIGN OF STRATEGIC, VALUE-ADDED BUSINESS PROCESSES, AND THE SYSTEMS, POLICIES, AND ORGANIZATION STRUCTURES THAT SUPPORT THEM, TO OPTIMIZE THE WORK FLOWS AND PRODUCTIVITY IN AN ORGANIZATION,"* (MANGANELLI, 1994).

- THE EMPHASIS ON STRATEGIC AND VALUE-ADDED PROCESS REDESIGN IS SO THAT ONLY THE PROCESSES THAT ARE OF ESSENTIAL IMPORTANCE TO AN ORGANIZATION ARE GIVEN CONSIDERATION.

- THE BASIC TENANTS OF RE-ENGINEERING IS THAT IT USES "DISCONTINUOUS THINKING", THAT IS IDENTIFYING AND ABANDONING THE OUTDATED AND FUNDAMENTAL ASSUMPTIONS, OLD PARADIGMS, THAT UNDERLIE CURRENT OPERATIONS.

RE-ENGINEERING (Continued)

- IT IS A HOLISTIC APPROACH EMPOWERING PEOPLE AND LEVERAGING TECHNOLOGY.
- RE-ENGINEERING IS NOT AN APPROACH THAT IS UNDERTAKEN WITH ENTHUSIASM. MOST COMPANIES UNDERTAKE IT BECAUSE COMPETITION IS THREATENING THEIR SURVIVAL.
- TO CLAIM THAT U.S. SHIPBUILDERS MUST UNDERTAKE RADICAL CHANGE IN THE WAY THEY WORK MAY APPEAR EXTREME, BUT IT IS BASED ON TWO FACTS:
    1. THERE IS NO OTHER APPROACH THAT WILL PROVIDE THE QUANTUM LEAP IN PERFORMANCE IMPROVEMENT THAT IS REQUIRED.
    2. IT HAS BEEN SUCCESSFULLY ACCOMPLISHED BY A NUMBER OF U.S. COMPANIES.

RE-ENGINEERING (Continued)

- WORK PROCESS CHANGE AND TECHNOLOGY BREAKTHROUGH ARE NOT NEW.

- WHAT IS NEW IS THE SYSTEMATIC METHOD FOR ACHIEVING SIGNIFICANT IMPROVEMENT THROUGH WORK PROCESS CHANGE AND THIS IS WHAT RE-ENGINEERING DOES.

- RE-ENGINEERING BECAUSE OF ITS RADICAL NATURE, EVEN MORE SO THAN INCREMENTAL CHANGE, REQUIRES A DISCIPLINE AND FRAMEWORK WHICH CAN CLEARLY AND REASONABLY PRESENT THE CASE FOR THE PROPOSED CHANGES.

- NO ONE IN THEIR RIGHT MIND IS GOING TO "BET THE COMPANY” ON AN IDEA, NO MATTER HOW GOOD IT IS.

I

RE-ENGINEERING (Continued)

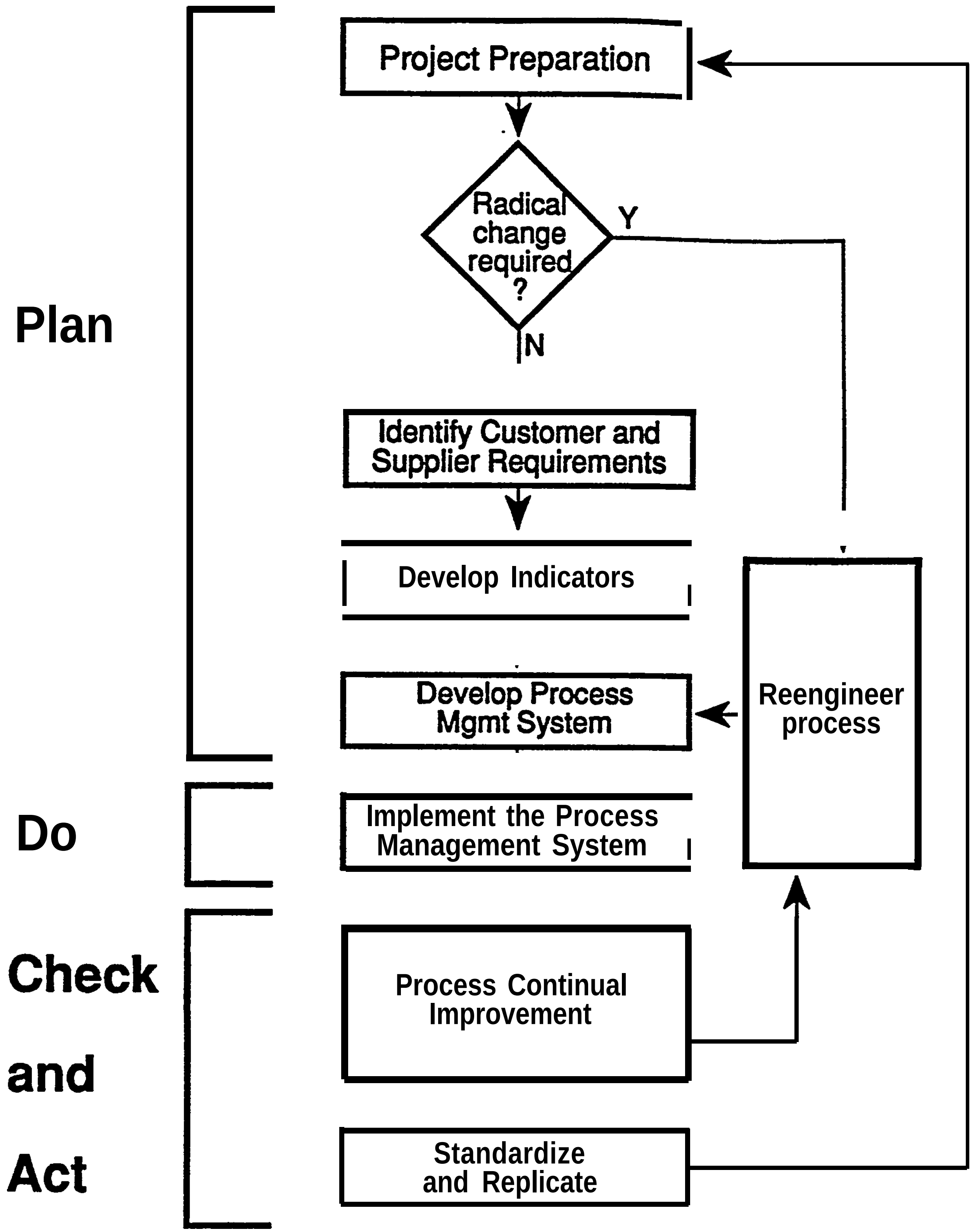
LESSONS LEARNED FROM MANY SUCCESSFUL AND SOME UNSUCCESSFUL IMPLEMENTATIONS ARE:

- **TOP MANAGEMENT MUST BE WILLING AND COMMITTED TO APPLY CHANGES TO THEIR OPERATION,**
- **MUST HAVE CLEAR AND MEANINGFUL VISION BEFORE YOU START CHANGING,**
- **THERE ARE MORE RESISTORS THAN SUPPORTERS OF THE CHANGES, SO TOP MANAGEMENT SPONSORSHIP IS ESSENTIAL,**
- **IT WONT BE EASY SO PERSEVERANCE IS A MUST**
- **CHANGE AGENT WILL PROBABLY BEAN OUTSIDER OR, IF WITHIN THE COMPANY, A RADICAL, AND**
- **RADICAL IMPROVEMENT IS POSSIBLE. IMPROVEMENT FACTORS OF 3 TO 5 ARE ATTAINABLE AND A FACTOR OF 30 HAS BEEN ACHIEVED.**

RE-ENGINEERING VERSUS OTHER APPROACHES

APPROACH ATTRIBUTE	RE-ENGINEERING	RIGHTSIZING	RE-STRUCTURING	TQM	AUTOMATION
ASSUMPTIONS QUESTIONED	Fundamental	Staffing	Reporting Relation-ships	Customer Wants and Needs	Technology Applications
SCOPE OF CHANGE	Radical	Staffing, Job Responsibil ities	Organization	Bottom-up	Systems
ORIENTATION	Process	Functional	Functional	Process	Procedures
IMPROVEMENT GOALS	Dramatic	Incremental	Incremental	Incremental	Incremental

Reengineering and Process Continual Improvement



'Reengineering,' or Evolution Through Violent Overthrow

They grew organically, evolving through mutation and selection until they represented an ideal bureaucratic manifestation. They took the most time, employed the most people and added the least value. For years, thunderous plodding tended to obscure the swift and innovative. Then reengineering swept across the economic landscape like the comet that crushed the unsuspecting dinosaurs with its iridium-laden core. The landscape cooled. The time of the dinosaurs was over. The thunderous plodders sank into the tar of histoy, waiting to be culled from the muck for examination by MBAs in 10 or 20 years.

Reengineering's violent metamorphosis left communicators, technologists, innovators and adapters reborn in its wake. The remaining dinosaurs, transformed by the sudden evolutionay burst, clambered skyward. Their once ground-clad claws talonized and pointed toward the less fortunate of their old species. With their final demise, the talons turn once again introspective, fostering continuous measurable improvement in the airborne race.

Dan Rasmus
Western Regional Edtior
LaBrea Tar Pts, Calif.

"Reengineer what?" you may ask. "We didn't engineer it in the first place!" The science of evolution presupposes random, uncontrolled events. Much of our management, and almost all of our systems, evolved like amoebae in the pre-Cambrian sea. Reengineering asserts human control over the evolutionary process; it crafts and molds, examines and extricates. Reengineering represents the genetic engineering of management, an opportunity to arrest and direct the future.

Design the redesign

Because we failed to engineer in the past, the word reengineering is somewhat of a misnomer. Reengineering combines the exploration and rediscovery of the business with solid methods for eliminating work that adds no value to the product.

Reengineering methods are not new. Robert Seltzer, president of Meta Software, Cambridge, Mass., sees reengineering as using "something very old—the methods and approach of systems engineering . . ..people. machines, processes, and how they interact."

Many companies find themselves confounded by the myriad of efficiency-improving programs in the marketplace. Besides reengineering, these include Total Quality Control, Continuous Process Improvement, and Continuous Measurable Improvement, to name a few. Rick Belmonte, senior manager in the Los Angeles office of Peat MarWick Main's Nolan Norton subsidiary, thinks people try to make these ideas "either/or" propositions. Instead, Belznonte encourages his clients to see that "new, redesigned processes are there to be continuously improved."

Unlike some of the other methods, which can be tackled at department levels, reengineering involves the whole company. Seltzer advocates a focus on the business enterprise, with an emphasis on financial impact and benefits. But, he says, "People must want to participate. It's not just a way for financial people to squeeze dollars."

Belmonte adds to the business. management focus an effort to "stretch" goals. The classic "stretch goal" was to put a man on the moor by the end of a decade. That forced "out-of-the-box thinking" that actually made it happen. Goals inspire people to think of new solutions, to examine problems from different angles.

On the practical level, Seltzer points out that you should be ready to "deliver success in six to eight weeks, no matter how large the project. Build the business process and deliver suits, then scale up. But first nail down a success that everyone agrees is a success."

Some companies are trying to institutionalize reengineering approaches. John J. Holton, Unisys vice president of Strategic Accounts Marketing, introduced the "Unisys Seven Commandments of Reengineering" at the National Financial Managers Conference held in May. The commandments are

1. Thou shalt formulate and understand your objectives.
2. Thou shalt plan.
3. Thou shalt insist on working with experienced systems integrators.
4. Thou shalt be open.
5. Thou shalt not automate junk.
6. Thou shalt listen to the end-user.
7. Thou shalt not view new possibilities based solely on your organization's current skill set: reengineering means reeducation and challenging your team to stretch and grow.

Like Belznonte and Seltzer, Holtc emphasizes creative thinking and work reduction before turning to automation. "All of this [reengineezing]," Belmonte states, "should take place in an atmosphere of true leadership, risk-taking and empowerment."

Driving the technology **wagon**

At a recent conference in the Los Angeles area, it appeared reengineering had overstimulated some vendors' thinking. One sign read: "Reengineer Your Processes Through Imaging."

Technology, rightly or wrongly, often drives reengineering projects. I technology should not overshadow the methods of work simplificati new process design, or improving people skills. "Technology sh stimulate the thought process," says Belmonte.

No single technology will reengineer the process. Some companies are selling client/server concepts as re-

engineering tools—and they are, but not in and of themselves. Any technology that increases productivity or saves money should be on a short list of things to try.

Technology should begin to make its impact early in the solution phase of a project. It is a good idea to invite technology experts to ask things like: “What would happen if we scanned in those documents?” or, “Couldn’t we use an expert system for that?” Without an early emphasis on new technology, some potential solutions may be overlooked.

A tremendous advantage

I spoke with Ron Antinoja, project manager with Bechtel Software, San Francisco, at the 1992 American Association for Artificial Intelligence *Conference.* He asked, “What is the difference between a methodologist and a terrorist?”

Slightly befuddled, I answered, “I don’t know, what?”

“You can negotiate with a terrorist,” Ron replied. Those of you who have dealt with a hard-core IDEF or Structured Analysis and Design fanatic will understand Ron’s joke.

Methodologies add structure to reengineering projects. IDEF, because of its close ties to the military community, leads the charge for reengineering in aerospace. Unfortunately, IDEF is often used to document “as-is” processes for new contracts instead of being used to focus the reengineering efforts of the company. Reductions in the military budget and IDEF’s increasing acceptance in the commercial world may change that.

IDEF diagrams are ”a tremendous advantage,” Seltzer states, over competing methods. “They are easy to read. Simple rules govern the graphical layouts. People learn IDEF syntax

Many companies find themselves confounded by the myriad of efficiency-improving programs in the marketplace.

in a very short time. One company team learned to read IIDEF diagrams] in a class in two hours.”

Many methodologies concentrate on an information-systems view of the world. Everything is either a process or data. Input data, transformed by a process, become output data to storage or to another process.” IDEF can also document inputs and outputs, but it takes in controls and mechanisms, too. Use of the method ensures that if too many pieces of paper are used in managing a process, this will soon be apparent.

Often, someone’s first exposure to IDEF is by way of presentation of hundreds of pages of diagrams. According to Seltzer, that approach doesn’t make much *sense.*

“Don’t go into too much detail unless what you are looking at is important.” Detail should be taken in small chunks, and examined by people who understand the process under scrutiny.

To validate the model, Seltzer encourages his clients to “look at one area within a project, take a subset, and then test, simulate and implement some changes.”

The old and the new

The IDEF methodology extends well beyond the analysis diagram known as lDEFO. Older accompanying methods include IDEF1 and IDEFIX for data modeliig. New methods, some still in development, add simulation, object-oriented design, process flow descriptions, ontology development and design rationale. The contract for development of the newer technologies was awarded to Knowledge Based Systems (KBS), College Station, Texas, as part of the Integrated Concurrent Engineering project supported by the U.S. Air Force.

Having robust modeling techniques, however, doesn’t make good models. Seltzer reminds us that “models are not reality, but abstract representations. Models must be validated

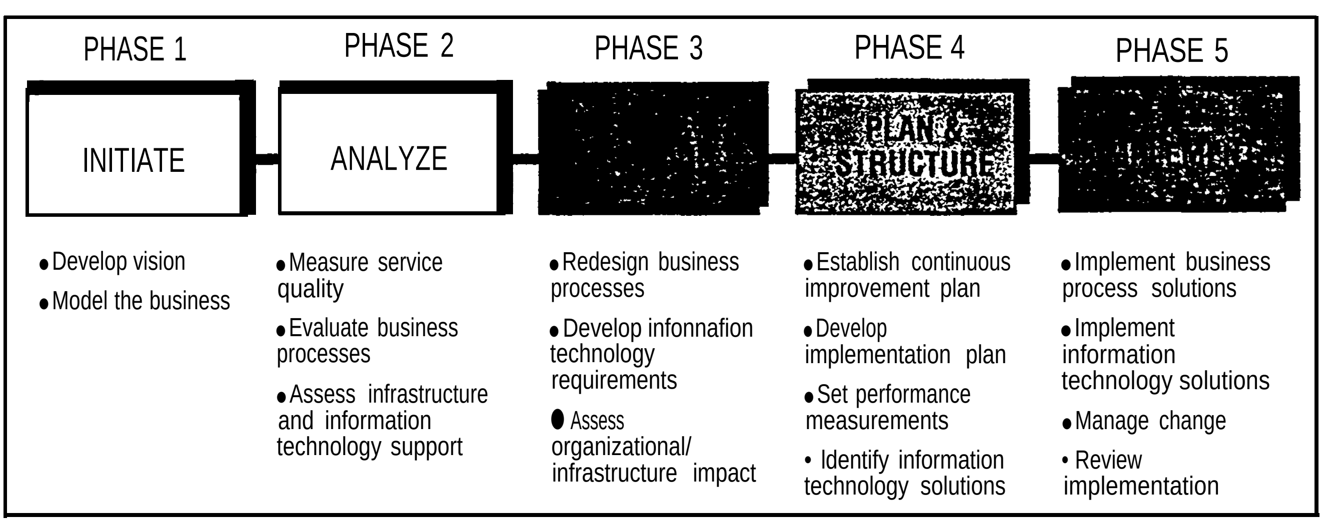


Diagram from Dun & Bradstreet Software illustrates business reengineering process in which corporate wide work-flow processes are completely

for their given focus and purpose."

Therefore, Seltzer first has his teams show the model to people who know the process and ask if it is right. Once the model is confirmed, the teams ask for feedback on relationships between tasks and time, thereby gathering behavioral detail, including concurrency. They then use Meta Software's Design/CPN Colored Petri net system—a graphically based simulation technology for performance evaluation and validation testing of large, complex models that involve concurrency-to simulate the IDEF process model. They pump in real data and chart model results against actual results. The final model includes sophisticated graphic and numeric analysis to prove if a model is valid, or to see how changes to a model affect the future state of affairs. When the model's results are close to the actual ones, they know it is explicit enough to be used to demonstrate how the process really works.

Seltzer adds, "Good simulations let you test .a hypothesis. How much money will it save? How much will it cost to implement?" lDEF doesn't take the modeling process into the systems design realm-at least not yet. IDEFIX creates data models, but IDEFO models don't generate details like structured pseudocode, found in more systems-oriented methodologies such as information engineering. The object-oriented extensions should combine process with data more tightly, but relational data bases and other solutions will require methods outside the IDEF family for actual computer system implementation.

Tooling up

Most reengineering methods evolved as paper models, not as computer programs. Now a wide variety of tools exists for PCs, Apple Macintoshes and workstations. The most popular tools constrain your creativity to the rules and syntax of the methodology.

Meta Software's Design/IDEF implements the IDEFO and IDEF1/lX methodologies. It runs on both the Macintosh and IBM PC under Windows. IDEFO diagrams consist of a series of boxes with lines and arrows that represent inputs, outputs, controls and mechanisms. Design/IDEF supports menus for creating all elements and ensures model consistency through interactive alerts for syntax violations. It includes all the elements to create accurate, complete and esthetically pleasing diagrams in a constrained drawing environment.

KBS approaches IDEF graphically,' but from a functional viewpoint. The KBS tool AIO develops diagrams from functional descriptions of the models.

A built-in drafting knowledge base incorporates illustration rules to generate diagrams automatically. David Rice of KBS says this method "enforces the modeling rules. By handling the drawing, AIO lets analysts concentrate on system modeling, not on the placement of boxes or the style of fonts." AIO uses artificial intelligence (AI) representation methods to capture the relationships in the model.

AI0 Professional includes a hypertext note feature, multiple model integration and graphic output that supports PostScript for Macintosh or Windows publishing programs. KBS sells a personal version of AI0 with fewer features and a limited model size. Similar tools for IDEF1 and IDEFIX are also available from KBS. The personal versions of the KBS products integrate completely to support the company's team concept of model development.

Both AI0 and Design/IDEF contain dictionary functions. AI0 creates its dictionary automatically from the analysis process. Design/IDEF requires end users to construct the dictionary.

Others in the act

One of the most unique applications at AAAI-92 came in the form of DECmodel from Digital Equipment Corp. (DEC), Marlboro, Mass. DECmodel incorporates symbolic representation from AI with practical simulation. It employs a highly graphical Motif interface that allows domain experts and DEC modelers to create models quickly.

If you are the president of the company, inventory control looks signifi-

Defining IDEF

The documentation and process improvement methodology known as the ICAM Definition Methodology, or IDEF, was developed by the U.S. Air Force to support its Integrated Computer and Manufacturing (ICAM) program. Dennis Wisnosky, an early participant in ICAM and the founder of Wizdom Systems, Naperville, Ill., sees IDEF as a way to identify what you need to do (IDEF0), identify what you need to know to do what you need to do (IDEF1/1X) and identify when you need to know what you need to know to do what you need to do.

IDEF now comes in many other flavors. The most recent additions push it past static designs and relational data models into the world of objects and simulation. Although IDEF is targeted at CIM in a discrete environment, it has been applied to a wide variety of business processes from banking to the process industries.

There are six IDEFs that either exist or are currently under development.

IDEF0 captures functional requirements and is the most commonly used of the IDEF methods. It represents processes as a series of boxes connected by inputs and outputs. Unlike other data flow methods, it also captures the why and who through its control and mechanism notations.

IDEF1 is an analysis tool that identifies the information in an enterprise, the rules governing its management, and the logical relationships among the information. It helps point you toward problems caused by inadequate information management.

IDEF1X is used to design relational data bases.

IDEF2 defines a graphic simulation language for the translation of IDEF0 models into dynamic simulations.

IDEF3 captures the behavior of objects in an enterprise through process flow descriptions and state transition diagrams.

IDEF4 adds object-oriented data modeling for use in newer applications where relational technology may be insufficient to describe the data.

IDEF5 supports a common framework for large projects by defining a repository of conceptual information to be used across functional boundaries.

IDEF6 captures design intent, or the knowledge and thinking that went into framing the other models.

puller in a warehouse. The object-oriented background of DECmodel easily displays multiple logical views of the same process. DECModel's use of AI and graphical interfaces synthesizes techniques and methods for improved process modeling.

As with any endeavor, the tool you choose is not as important as the thinking that goes into the model. IDEFO is a paper technique enhanced and hastened by computers, but it is by no means dependent on them. Dynamic modeling, though possible without a computer, is too slow to be meaningful without one. The integration of design, analysis and execution models promises to enable speedier, more accurate and more meaningful model building for business managers and executives.

A basic principle

At some point, you may hear the cry "If I've reengineered it once, I've reengineered it a thousand times!" Hank Holland, president of Dun & Bradstreet Software, Atlanta, is concerned that "business reengineering may sound like a lofty concept." He reassures his customers, "Actually, it is a basic principle to evaluate your primary business, and then look at how that primary business could function better, regardless of the

As with any endeavor, the tool you choose is not as important as the thinking that goes into the model.

methods or procedures already in place."

Like so many new business drivers, whether they be called business process reengineering business process improvement or business process redesign, reengineering relies on firm management support and an open, creative atmosphere.

After looking at a D&B Software study on reengineering, Terry Rapoch, vice president of corporate systems and planning at Rogers Communications, Toronto, commented, "This survey makes clear that people feel business must continue to evolve in order to survive and reengineering is simply another way to describe this evolutionary imperative."

That returns us to brontosaurus, hadrosaurs and iguanodons. The globalization of the economy, the rise of the Pacific Rim, the unification of Europe and the dissolution of the Soviet bloc have disrupted post-World War II economic assumptions with an impact equal to the Cretaceus/Tertiary boundary catastrophe that rocked the mammals into dominance. But unlike the dinosaurs, our way of doing business need not succumb to random natural events: *Our* destiny, remember, lies in the intricate pattern and exquisite detail of the human mind.

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BUSINESS PROCESS RE-ENGINEERING

- **EVEN THOUGH SOME AUTHORS USE IT TO DESCRIBE THE SAME THING, IT IS MORE THAN ANOTHER NAME FOR RE-ENGINEERING**

- **EMPHASIZES RE-DESIGN OF PROCESSES NOT JUST RE-DESIGN OF ORGANIZATION STRUCTURES AND JOBS**

- **INCLUDES PREDICTED PROCESS IMPROVEMENT AS THE METRIC TO BE USED FOR SELECTION OF BEST PROCESSES**

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
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Shipyard Re-Engineering

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ABSTRACT

Change has been a watchword for U.S. shipyards for many years and change has taken on many different meanings as shipyard technology and management techniques have evolved. A recent survey [1] of several major shipyards around the world indicates that all shipyards recognize that change is required to compete, but they have not been able to overcome some of the important barriers to change that are necessary to increase their profitability.

The purpose of this paper is to introduce change as a pathway to growth through process reengineering and organization transformation. Using a framework of proven management tools and techniques. the phases and steps of successful reengineering and reorganization procedures will be matched to specific issues facing U.S. shipyards today. Finally. recent experience with reengineering and reorganization in other industries will be used to identify opponunities that can be incorporated to help shipyards change.

REENGINEERING IS THE FIRST STEP IN IMPROVING A FIRM'S PERFORMANCE

With reengineering being the current choice of CEOS for creating large-scale process change. its fundamentals and techniques are commonly known in all industries. The successes and failures of new process implementation are not well known. The shipyard survey shows that most shipyards have identified process improvements, but few have indicated that they have successfully implemented the changes. Thc uncertainty of the success or failure of the process improvement actions does show that the changes lacked one of the most important elements of reengineering and reorganization, an ***accurate performance measurement system*** (Figure 1). Experiences in ***other*** industries show that if a new process is delined and implemented properly, the performance metrics established as part of reengineering will provide early indications of its success or failure.

New production techniques over the past 30 years have helped shipyards improve the productivity of their work force and shorten the building cycle of most ships. During their involvement in Naval construction, most U.S. shipyards incorporated some of these productivity improvements to reduce construction costs. but they have yet to employ them effectively in commercial production. The shipyard survey indicates that shipyards have tended to focus on incremental process improvements, namely cost reduction and quality initiatives (Figure 2). Because these initiatives lacked clear customer focus and vision for the business, as well as a framework to guide process change, they did not deliver the kind of quantum leaps in performance normally associated with true process reenginecring.

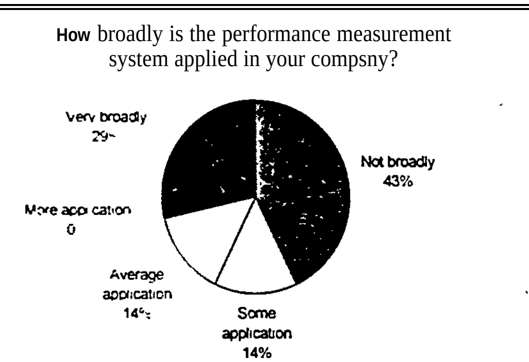

Figure 1

1 Conducted by Mercer Management Consulting In April 1995

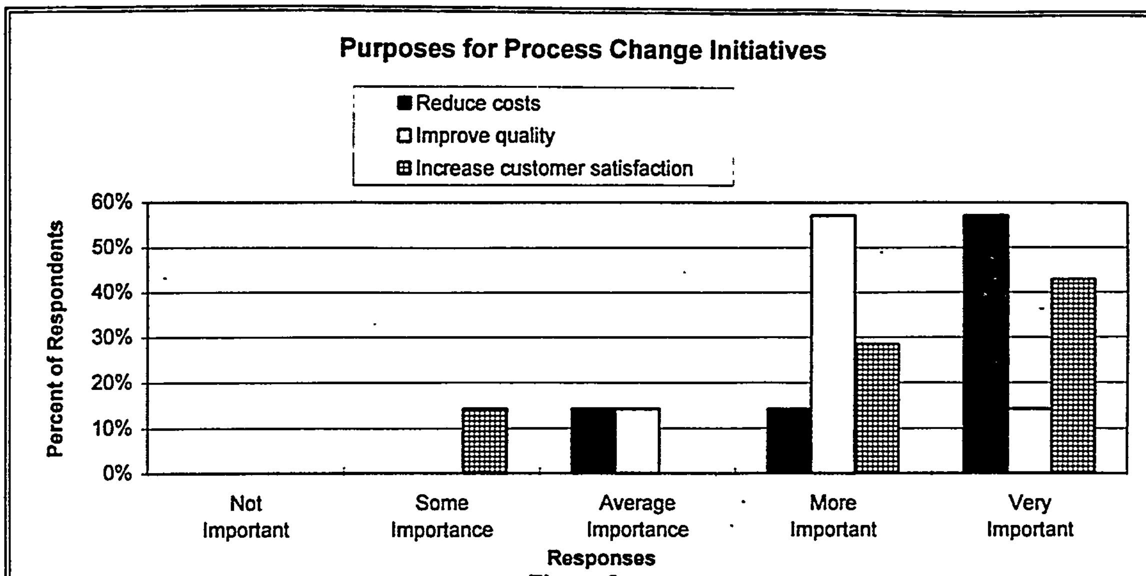

Figure 2

The survey (Figure 3) also shows that shipyard management is not focused on improving company performance through growth. While there is strong agreement that real growth is difficult in the industry, growth appears to be a low priority as part of company strategies.

The framework for performance improvement and growth includes three significant steps for achieving sustained improvement and profitability (Figure 4). We will address the first two steps in this paper. With the products of successful process reengineering and organization transformation in place, shipyard managers will be able to reassess their growth potential.

CORPORATE PERFORMANCE IS CHALLENGED ON MANY FRONTS

The external pressures on corporate performance include competition, customer service requirements, government regulations and changing technology. All of these forces have a direct impact on the internal processes in any industry. Shipyards clearly face most of these challenges.

External pressures on U.S. shipyards

Competitive pressures: Competition no longer comes from a few other U.S. shipyards submitting proposals for Navy shipbuilding and repair contracts. When competing for Navy work, bid strategy was

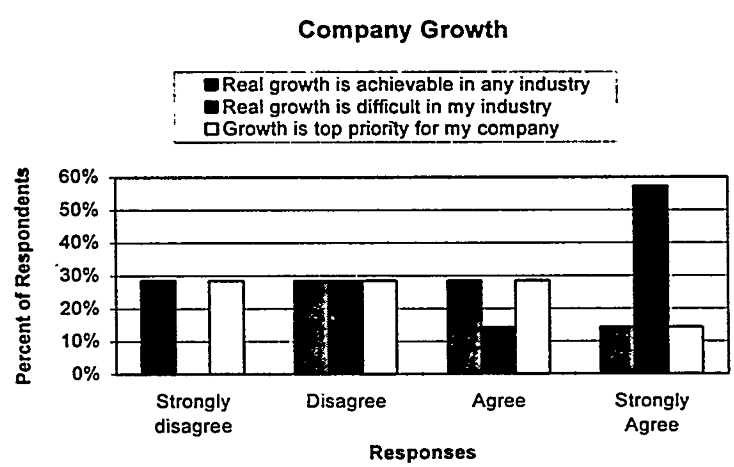

Figure 3

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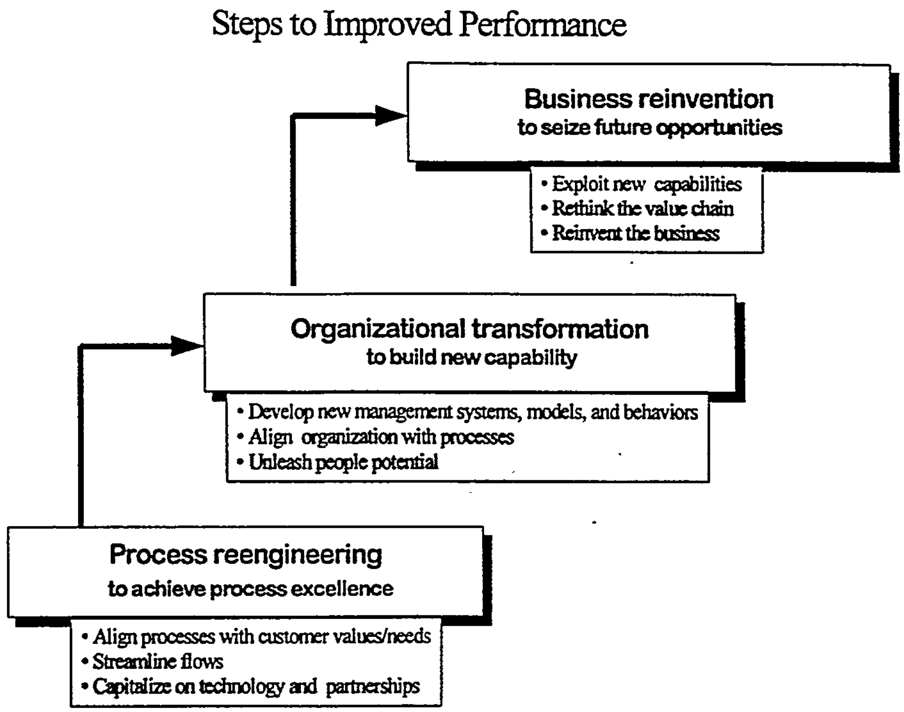

Figure 4

focused on how the competition might respond to the request for proposal (RFP) and not on the customer. Now, competition for commercial work comes from foreign shipyards as well as other U.S. shipyards. It is further complicated by the need to seek out customers instead of always being on government bidders lists.

Customer **service gaps: Who** are these new customers and who defines value for them? U.S. shipyards need to determine where and how to interface with the new commercial customers. They also need to know how to attract and retain them.

Regulatory **changes:** Shipbuilding and repair will always be subject to national and international regulations. The whole subsidy question \vill remain complex and unresolved for as long as nations continue to support their shipbuilding industries. Federal assistance for the industry will vary from administration to administration. Environmental regulations and agreements have had significant impact in recent years and will remain a dominant force in shipbuilding decisions. If a shipyard organization is not tuned to handling these regulatory changes as part of its normal routine, it will not survive.

Changing **technology:** Changes in vessel designs. new construction techniques, advances in automation and robotics, and information management have usually been the forte of progressive shipyards around the world. U.S. shipyards have not always been the leader in new technology, but they have eventually incorporated the changes whenever they fit into the Navy contracts.

In addition, shipyards face challenges internally

Processes: Existing processes have been developed for warship construction and repair. Many of the required processes for commercial work do not exist in U.S. shipyards and other processes are not focused on the new customers. As a result, the existing processes are too costly and take too long to complete.

Organization: Many existing organizations are too large for efficient communication and execution. They are bureaucratic, hierarchical, and not aligned with business strategy or processes. Most of the roles and responsibilities are not clear and the typical hierarchical shipyard organization fails to push responsibilities down to the value adding managers in the processes.

Technology: There is too much reliance on manual methods and the information systems that do exist often do not support flexible processes. Decades of relying on government work has also limited the ability to update plants and equipment. There has also been a failure of management to fully commit to improved technology.

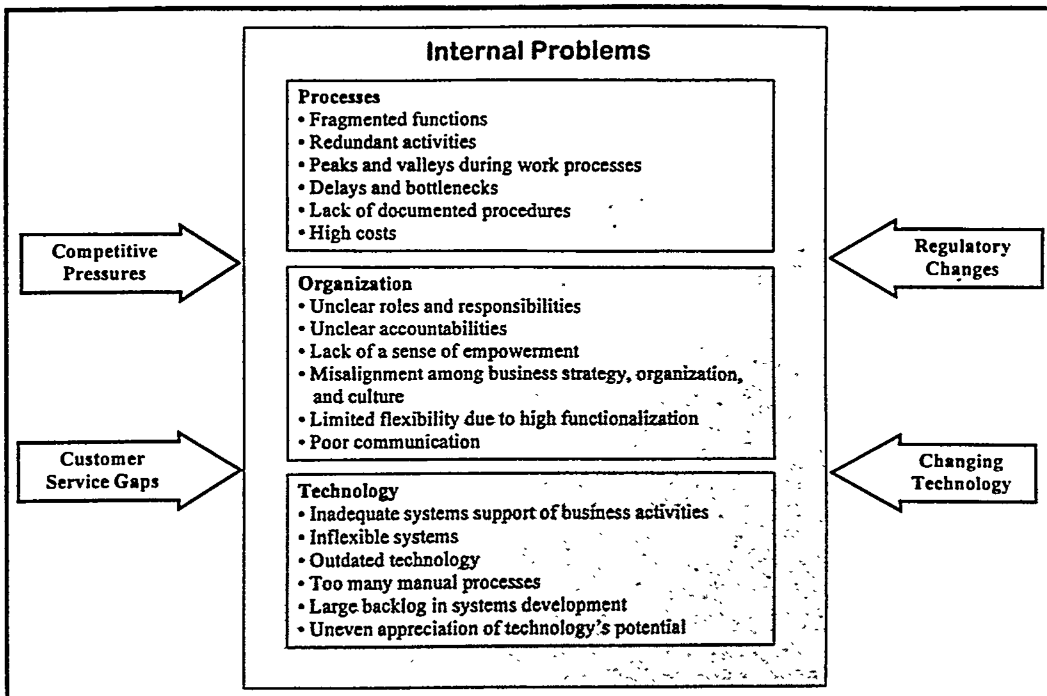

Figure 5

Figure 5 illustrates pressures facing shipbuilding and repair.

PROCESS REENGINEERING

Process reengineering is a structured approach to change. It is designed to achieve a quantum leap in business performance and position by redesigning core processes to better serve customers. The authors have successfully reengineered shipyard processes that integrate many of the process improvement techniques that have become familiar to those organizations that have worked with Total Quality Management, Concurrent Engineering, and other Continuous Proces Improvement programs. While these other program have improved many components of shipyar organizations and brought new recognition to th concept of employee empowerment, they often fail t focus their extensive efforts toward a commo measurable goal of corporate profitability and growt (Figure 6). Furthermore, we have found that the man different process improvement programs compete fo valuable personnel assets and often have conflictin goals in many corporations.

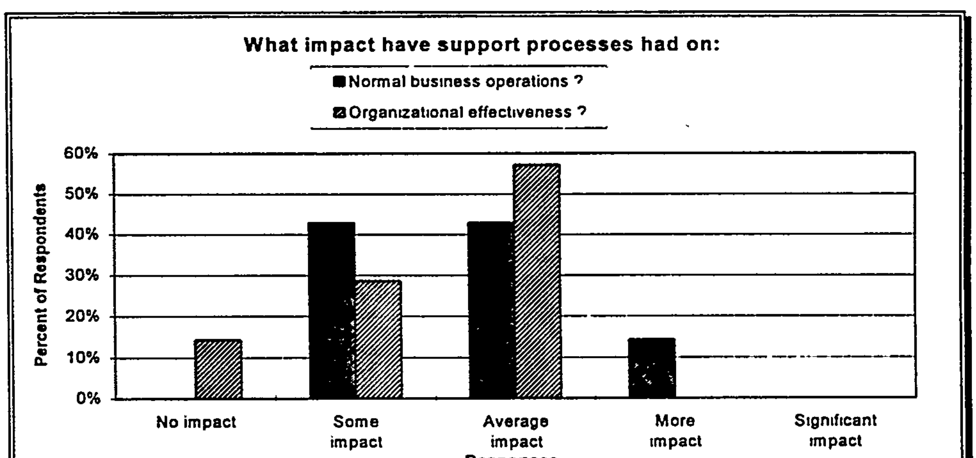

Figure 6

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Management of the changes that are introduced through reengineering requires adoption of several basic principles (Table I). Continuous review of these principles will help stimulate the creative and "out-of-the-box" thinking that is necessary for successful reengineering efforts, as well as keep the focus on customer value and satisfaction as key drivers of reengineering implementation. A methodology which incorporates these principles utilizes 12 basic steps in four phases to thoroughly define, design and implement the new process. The four-phased approach to process reengineering begins with mobilizing resources and ends with implementing reengineered processes based on customer requirements. Throughout the project, the shipyard must address ***process,*** *organization, and* ***/echnology*** issues. In addition, procedures for effective *communication and management of change* must be implemented during all four reengineering phases and beyond. Figure 7 illustrates an effective incorporation of the 12 steps in the four phases of reengineering.

Phase 1: Mobilization

The ground work for reengineering is laid during the mobilization phase. It begins with the development of support for change at all levels of the organization. Workshops and training sessions are conducted with the senior management coordinating committee and individual reengineering team members. During these first few sessions it is important to:

- Identify and leverage related initiatives
- Ensure management commitment
- Establish a communications plan

Table I
Principles of Process Reengineering

1	Base the process design on Customer Value.
2	View the business as a set of processes that cut horizontally across the company and its affiliates to serve the customer.
3	Think broadly, considering how technology, people, and processes act together and separately to influence change.
4	Don't be constrained by tradition. Be open and willing to learn from best practices both inside and outside the organization and the industry.
5	Look at the full value chain, taking into account the role of distributors, suppliers, and customers.
6	Focus resources where real value is created. Consider outsourcing work that could be better performed externally.
7	Build a foundation for continuous improvement by tracking and communicating progress and rewarding results.

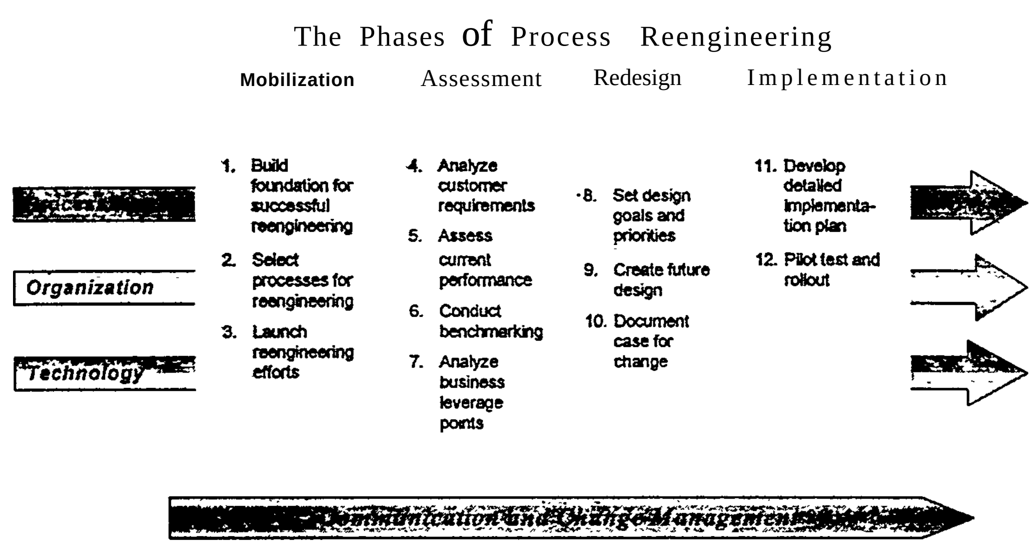

Figure 7

Once the reengineeri.ng teams are trained and are working from a common base, they can start selecting processes for reengineering. These sessions will require management interviews, development of diagnostic techniques, careful prioritization of processes, and focus on the company's strengths and opportunities as well as any existing process gaps.

The selection of processes to be reengineered will allow the reengineering teams to begin to prepare the overall project work plan and prepare high-level process maps. As with any large project involving personnel from all elements of the organization, the success or failure of the project will be determined by the care and effort that is put into the mobilization effort. The follow-on phases will depend on how well the support network and culture for change are established at the very beginning of the reengineering effort. Several mobilization issues that are specific to shipyards are identified in Tables 11 and III.

The conversion from military to commercial construction and repair processes represents additional special mobilization issues for U.S. shipyards. When the reengineering team develops the high-level process map they will have to compare existing military oriented processes with those required for commercial work.

Phase 2: Assessment

The second phase of process reengineering requires a careful assessment of the existing process and the customer requirements. Baselines and benchmarks will be established, current performance measured and performance targets defined during the assessment phase. The reengineenng teams will map existing processes and use various analytical techniqu to measure and verify the cycle time of each process. By the end of the assessment phase. the teams must have a clear understanding of the custome requirements and where the current processes fail t meet the performance targets.

U.S. shipyards must be especially careful to address the specific assessment issues that have caused implementation problems during previous reengineering efforts (Table IV).

Phase 3: **Redesign**

The reengineering teams must move "out-of-the-box" during the redesign phase in order to create new processes that will make quantum leaps to new performance targets. However, a structured procedure must be followed to ensure that the basis for the new design is well documented. It will be the reengineering team's responsibility to present and obtain management buy-in for the new process. Thev will have to thoroughly demonstrate the benefits relative to costs.

Redesign issues that U.S. shipyards face are

Table II
Mobilization issues for shipyards

Senior management must make a profound commitment to change.	• "All show, no go" won't work • Marketing versus Reality
Consider the results of previous TQM initiatives.	• Reengineering will help to link many of these previous quality improvement projects • Focus on quality issues that meet customer expectations
Explore the possibilities of Maritech or other assistance, but...	• Can you wait that long? • Will it get you where you need to be?
Be sure the team(s) selected represent a cross-section of the organization, including:	• Production • Engineering • Finance • Quality • Material
Do some up-front education (if required) on brainstorming, quality, and customers.	• All reengineering team members and management should have an equal understanding of the techniques and tools • Defining customer requirements (internal & external) is not an easy task
Be sure the teams understand the time commitment.	• Primary team members should consider reengineering their primary responsibility for the duration of the project • The initial reengineering and associated reorganization should be accomplished in the shortest possible time period

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Table III
During mobilization, the Reengineering Teams will have to consider processes that:

?	*Are the same for both military and commercial*	*Are radically altered to suit commercial contracts*	*Do not currently exist but must be created to support commercial construction*
Examples	• Pipe shop • Steel fabrication	• Steel assembly • Pre-outfitting	• Sandwich construction • Coordination with joiner contractor • Super block construction
Implications	– Ensure no capacity constraints – Look to world standards for performance – Use technology to quickly close performance gaps	– Process reengineering is well-suited to this category	–A perfect opportunity to leap-frog the competition –Be sure the benefits justify the costs –Radically new processes may indicate that there is a need to revisit other processes to ensure a good "fit"

similar to other industries, but because of the strong ties to traditional building techniques, establishing aggressive performance targets and breaking out-of-the-box are particularly challenging. Specific issues are shown in Table V.

Phase 4: Implementation

The implementation of the new processes will provide the first real test of how well the shipyard organization, management and employees are ready to accept change. To make the quantum jumps in performance, all levels of the organization must be involved in the implementation of the reengineered processes. The new tasks and responsibilities for implementation will affect every function in the shipyard (Table VI).

Planning for implementation of reengineered processes should be similar to any new shipbuilding project. It will require training workshops and planning meetings to introduce the new processes and the

Table IV
Assessment issues for shipyards

Be sure you know who the customers are and how they think.	• Clearly communicated and quantifiable strategy • Detailed and organized knowledge of how your customers define "value"
Many U.S. shipyards are a long way from having activity-based costing.	• Difficult to find current process metrics • Personnel are not comfortable with rigorous performance metrics and analysis
Be sure your benchmarks are truly best-in-class.	• Look to other industries for best practices • Establish aggressive benchmarking procedures
Benchmarking is a formal, rigorous, and analytical process, not a series of field trips, and it requires:	• Thought time • Money
Leverage points (cost drivers) should be considered in the context of the business mix to retain flexibility.	• How do they fit corporate strategy? • Are they related to value added activities?

Table V Redesign issues for shipyards.	
Performance targets must be aggressive (since the industry isn't used to quantum anything).	• A well conducted benchmark program will provide the targets • Internal performance targets must be aggressive too
Getting people to think "outside-the-box" is enormously challenging.	• Old hierarchies and walls are hard to break down • Establish team membership to reflect applicable demographic and cultural issues.
Data to support the cost-benefit analyses will be even harder to collect than the current process metrics.	• Well documented assumptions may be required • Be conservative when preparing estimates and always use a "Test of Reasonableness"
Pull out quick fixes and implement.	• Nothing succeeds like success! • Don't hesitate to make obvious improvements, it will help to establish the new culture
Don't dismiss or discourage at this point - the teams must have complete freedom to design optimal processes.	• At this stage of reengineering, creativity may not be as high as at the start • Reaffirm objectives and customer requirements
Get senior management feedback and buy-in regularly.	• It's absolutely necessary for the reengineering of complex shipbuilding processes. • Reengineering must receive high priority at all levels of management to be effective.
Prioritize opportunities based on cost/benefit analyses.	• Priorities will shift as cost/benefit analyses are completed. • Thoroughly prepared cost/benefit analyses are very important to properly evaluate shipyard growth opportunities.

performance measurement tools that will be used. Many portions of the process may require pilot testing before they are fully refined. A detailed implementation schedule will be required to help minimize start-up delays and costs.

Shipyard reengineering does not end with

Table VI Implementation issues for shipyards.	
Don't be afraid to pilot-test redesigned processes.	• Prove the costs/benefits (they're probably more positive than you thought!) • Find even better ways to do things.
Avoid automatically giving priority to big capital items.	• Payoff is usually not as attractive • These items can reduce flexibility if not thoroughly studied and understood • Harder to get approved by senior management, board, shareholders
Don't let opportunities that were not the "cream" be forgotten.	• Less attractive opportunities for reengineering are still important links in the overall shipbuilding process • Investment constraints may force the use of lower priority opportunities.
Establish a Project or Implementation Team, and design clear responsibilities and milestones for implementation.	• Design clear responsibilities and milestones for implementation. • The Implementation Project Team should have at least an equal status with any shipbuilding or repair project.
This is not the end of reengineering!	• Implementation can take years, especially to see significant results • Senior management must continuously reinforce commitment • Don't let the first commercial contract distract teams from continuing the process

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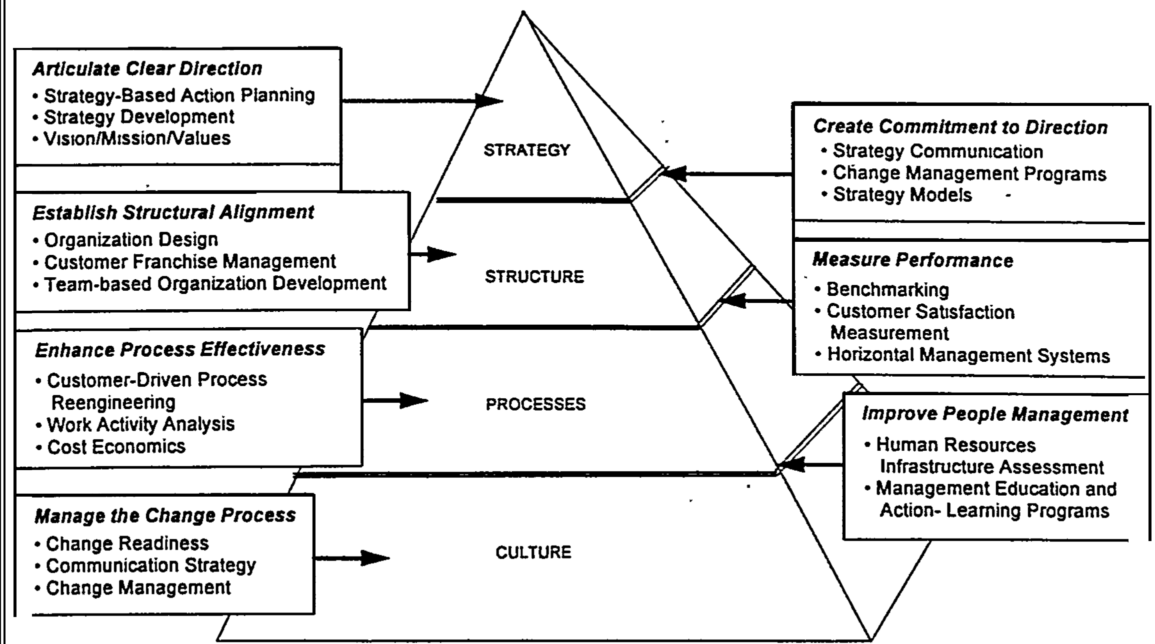

Figure 8

implementation of the new processes; provision must be made for continuous improvement. Many of the same tools and techniques used during the mobilization, assessment, and redesign phases will be incorporated to continually refine the processes.

The performance measurement system for each new process must be integrated into routine shipyard management productivity and cost control procedures. With effective change management and continuous process improvement mechanisms in place, areas for process improvement can be quickly identified and action taken without disruption to the overall shipbuilding process.

ORGANIZATION REDESIGN AND TRANSFORMATION

Aligning Structure, Processes, and Culture with Strategy

Given company differences in alignment across the dimensions of corporate performance, organization change solutions must be customized to each particular situation. Company performance can be depicted as a pyramid with corporate culture at the bottom, strategy at the top and the processes and organization structure joining the top and bottom in a well defined dimensionally correct entity (Figure 8).

The strategy must articulate clear direction to establish the core competencies and focus all efforts toward selling the resulting products, even if it is no longer a whole ship. It must also ensure that all internal customer expectations are aligned to overall process improvement. The survey (Figure. 9) indicates that shipyards do not effectively communicate company strategy to process stake-holders.

The organizational structure must be aligned and consistent with the processes, facilities, skills, and work force assignments to meet customer needs. The organization must support continuous process improvement and change.

Process effectiveness will be enhanced by performance measurement systems properly designed to reinforce a continuous process improvement plan. Measured success in one element of the shipbuilding/repair process should be traceable to performance improvement in the overall process.

Change must be considered a constant in a growing enterprise. Without the ability to manage it. the growth may be in the form of a step function instead of a smooth upward curve. Since shipyard growth curves are relatively shallow, any slow downs

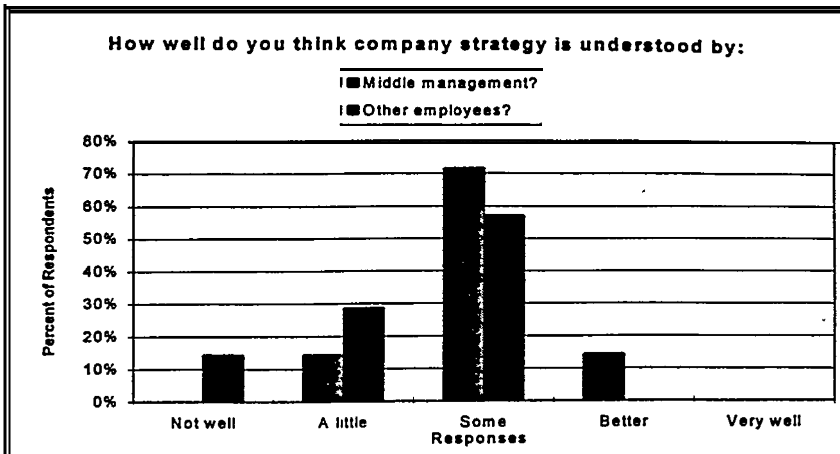

Figure 9

or loss of profit as a result of poorly planned process change could be disastrous. Initially, process reengineering and organizational realignment may mean disruption to normal productivity. However, if the reengineering and organizational adjustments are planned and implemented correctly, any future changes should only result in improved performance with full value realized from any associated startup costs.

Organization redesign and transformation need to take place in conjunction with, or immediately after, the first fill-blown reengineering activity. The core principles of organization redesign (Table VII), like the guiding principles for reengineering, include

- Organization aligned with the corporate strategy,
- Employee empowerment at all levels, and;
- Customer focus

These principles provide a basis for evaluating organization alternatives.

Organizational Redesign and Transformation at U.S. **shipyards should be considered a priority**

Shipyard organizations are not currently aligned with processes (whether optimal or not). Tradition remains strong in the industry. Regardless of how many times a shipyard has introduced elements of change, the overall construction process remains tied to traditional shipbuilding technology. The change elements have helped to improve the productivity of key components in the overall construction process, but most of the process control features have not changed. As shown in Figure 10, the majority of the survey respondents did not feel that their organizations supported the two key elements of process improvement: the company's goals and objectives an worker empowerment.

Shipyard decision making takes place at **the** top. Process knowledge is in the hands of the process participants and not senior management. In fact, senior

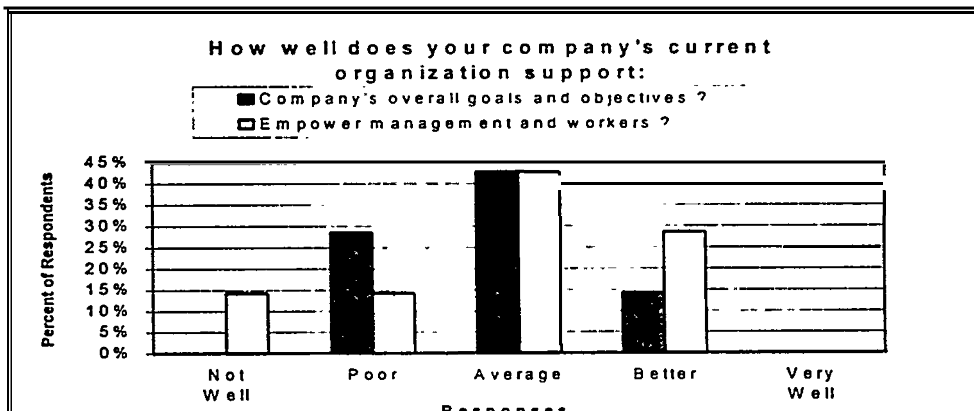

Figure 10

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Table VII Core Principles Organization Redesign	
Structure should support strategy.	. The company's organization structure should be closely aligned with its major mission and strategic objectives. ● Structure and policy should permit decisions to be made at the lowest practical level to enhance their timeliness and responsiveness to the external environment.
Organizations should have the fewest levels possible.	. Fewer levels provide for better communication, faster decision making, greater adaptability to change, more satisfying jobs, and increased productivity.
Managers should manage.	● Professional management is a full-time job. Ž Full-time managers achieve effective deployment of resources, minimize overlaps of responsibilities, and focus on building the organization's human resources.
Managers should have appropriate spans of control.	● Every managerial job should be assigned a span of control standard, based on the mix of work performed. Ž Full spans of control provide meaningful management jobs and permit clearer delegation of authority and responsibility. • Small spans require more managers, increase costs, and add steps to the decision-making process.
Work should be focused on related activities.	● Employees should be able to see natural beginnings and endings to their work. • An individual's work should comprise tasks that are naturally related.
The majority of work activity should directly support the organization's mission.	● Work activities fit into four classifications: key (activities that fulfill the organization's mission or produce its defined output), managerial, administrative, and secondary. Ž Organizations devoting less than 70 percent of their time to key activities are usually compromising their potential.
Organizational analysis aimed at increasing efficiency and effectiveness should start at the bottom.	• Designing an organization that can effectively achieve its strategy requires starting at the bottom, where products are made and services are provided.

managers are often the last participants to accept change and throw off traditional building methods. While they may push for more productivity in the engineering and production shops, they will just as easily accept that the traditional barriers between engineering and production cannot be tom down.

When was the last time senior management considered the internal customers of the shipbuilding or repair process? They have probably responded to various requests for process improvements within individual departments, but have left the departments to work out their own intradepartmental differences. As a result, the shipyard may have a very productive Production Department and an efficient Engineering Department but a relatively non-productive shipbuilding process. While focusing on marketing of the shipyard and wooing external customers, senior management is ignoring the internal customers and process holders.

Senior managers will profess that they know the shipyard customers best. However, that knowledge is usually imperfect and based on broad market analyses or a request for proposal received in the mail from a ship owner. Because of their lack of commercial shipbuilding and repair experience, U.S. shipyards often fail to respond to the customers' needs and values. Shipyard planners spend all of their time trying to respond to a commercial RFP as if it were a US Navy specification and may not recognize what the ship owner is seeking in a business relationship.

Current shipyard organizations are too heavy, due to reliance on government programs. Despite recent efforts to shake off reliance on the US Navy, large, bureaucratic organizations have become part of the shipyard way of life. Previous organization changes have followed the path of process improvement within the individual departments and avoided the critical path of overall organizational change.

Excessive organizations manifest themselves particularly in administration and engineering. Dependence on government programs is usually reflected in the addition of new administrative or

engineering functions to meet the latest change in government specifications. Unfortunately, older, outdated functions are not eliminated at the same time. Organizational change to meet specific government specifications and imposed structure removes the organization's focus from its core competencies. As a result when government contracts are no longer sufficient to support the U.S. shipbuilding industry, any attempt to adapt the old organization to commercial work may be very unprofitable.

Current shipyard organizations have an unbalanced mix of skills to support commercial contracts. Recent U.S. shipyard experiments with process improvements have retained the skills used to produce or repair Navy ships, without viewing their overall organization as an opportunity to satisfy the needs and values of commercial ship owners. Current labor skills and facilities may be too light in steel construction and too heavy in electronics and sheet metal to be competitive with other shipyards. Similarly, the planning skills required for effective commercial construction programs are different from those required for Naval construction.

Most modern organizational concepts have not even been considered, much less implemented. With the focus on TQM and process improvement concepts such as horizontal management and self-directed work teams have been overlooked. In most organizations, it will be very difficult to implement reengineered processes if a process driven reorganization is not considered. Reengineered processes depend on effective spans of control, worker empowerment and "whole" jobs, all of which are lacking in many shipyards. The traditional approaches to shipbuilding and dependence on government contracts have encouraged function-oriented organizations instead of process controlled organizations; thus, associated work teams are controlled by a hierarchical management pyramid, instead of being tailored for the processes that they are performing..

Shipyard reward systems are behind the times. Without process oriented work teams and a horizontal organization to support customer-focused processes, shipyards have lacked a frarnework to develop effective reward systems for their workers. This is supponed by results from the shipyard survey. As shown in Figure 11, 50%. of survey participants noted that there was little or no link between performance measurement and their incentive and compensation systems. An additional 140%. considered that there was only average application of performance measurement to compensation.

A properly reengineered process will incorporate quantifiable performance measurement systems, able to track performance of each self-directed work team in the process and continuously show how well the work team supports overall shipyard productivity. The same system is readily available to be used for worker performance evaluations and compensation plans.

Performance Measurement, Incentive, and Compensation Systems

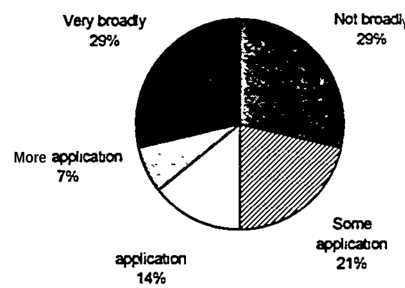

Figure 11

THE PATHWAY TO WORLD CLASS PERFORMANCE

Once processes are reengineered to meet customer expectations and implemented in an organization that supports the new processes, the shipyard should enjoy:

- Greater competitive strength;
- Improved organizational flexibility; and,
- Improved employee morale and capabilities.

They should also be in a position to continue to quantify and track these benefits as part of the performance measurement system established with the improved processes.

Greater Competitive Strength **Through Reduced Cost and Cycle Time**

Greater competitive strength should be realized through significant cost and cycle time reductions, improved product quality and service levels, and increased capability to meet customer needs. By focusing efforts on activities that deliver value, the shipyard can eliminate process activities that waste valuable operating dollars and increase the process cycle time. Redesigning across the fill value chain also provides the opportunities to establish partnerships with suppliers and customers to further reduce costs and cycle time.

By focusing the entire organization on delivering quality and service levels that meet customer needs (internal, external and across organizational boundaries), a shipyard can perform at the levels

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necessary to compete in the world market. By establishing easily measured processes during reengineenng, the shipyard can ensure maintenance of desired quality and service levels. The performance measurement system will also permit quick identification and implementation of corrective actions.

Competitive strength also depends on customer retention. With the reengineered processes and supporting organization aligned with customer values and needs, the shipyard will be in a better position to receive follow-on contracts and attract new customers.

When processes and the organization are focused on core competencies, the shipyard will be in a position to successfully compete in its defined market. Processes will support productivity improvements and cost reductions; the organization will be flexible and capable of adapting to customer's requests and expectations as well as the ever changing market place.

Improved Organizational Flexibility Through Cross-Functional Coordination and Culture Change

The flexibility of an organization can be measured by its ability to support cross-functional coordination and cultural acceptance of change. Cross-functional coordination and involvement in shipyard processes brings improved communication and capability to make changes faster. The principle function of the new flexible organization will be to define, redesign. and implement the changes necessary for continuous process improvement without disruption of the overall process.

Reengineering efforts are action-oriented and result in change. Improvement is continuously sought: making change an accepted and desired part of the culture will be easier when the organization is designed to support effective processes. When the organization is defined by the shipbuilding and repair processes. it will be able to respond to changes in technology and modifications to the customer's expectations The shipyard's processes will be able to support design changes with minimal disruption in production

Improved Employee Morale and Capabilities Through Process Directed Work Teams

Reengineered processes are dependent on open communication and a flexible organization that encourages more proactive involvement in meeting customer needs, broader jobs with greater empowerment, and improved effectiveness in managing work processes. Communication improves through interaction among individuals from different functions in the organization. Reengineering success provides - motivation for continued improvement. Organization structure and technology must support. rather than hinder, the processes.

The organization must focus on the common goal of meeting customer needs and then receive feedback from performance measures. The roles and responsibilities of all shipyard personnel are defined to support the shipyard processes and customer needs, making it easier and less ambiguous to deliver value. With appropriate roles and responsibilities, each person knows where they fit into the shipyard processes and how their performance affects the quality and service delivered to the customer.

Processes with greater worker empowerment will have reduced cycle time because they will require fewer hand-offs and decision delays. The employees \vill acquire multi-functional skills and there will be an increased emphasis on learning and improvement: performance measurement and reward systems must be consistent with the new job structure.

LESSONS LEARNED FROM REENGINEERING PROJECTS IN U.S. AND FOREIGN SHIPYARDS

This paper has put forth a fratnework of concepts and techniques for process reengineering and organization transformation that have been successfully used in other industries. This experience can be summarized in Table VIII by a few simple "do's and don'ts." that shipyard management should consider when developing a strategy for change.

Table VIII
Considerations for Developing a Strategy for Change

Do	Don't
• Get started now - radical change takes years to implement fully. • Staff the teams with rising stars (who are seemingly too busy to ever be able to afford the time). • Encourage the teams to "think by walking around" - conference rooms are not conducive to creative thinking. • Involve all levels of the organization, including hourly workers and union officials, right from the start. • Consider using an outside change agent (after all, it's not one of your core competencies). – Faster cycle time – Greater integration across the fire – More likelihood of buy-in at all levels – Focused and enthused	• Don't put too many senior people on reengineering teams - they tend to intimidate and stifle out-of-the-box thinking. • Don't expect people who are not trained analysts to become instantly proficient - give teams the support they require. • Don't think that radical change: – Happens without a plan – Can be done just like building a ship – Is intuitively obvious, so it will get done "automatically" • Don't think that reengineering is only about automation and other big capital projects - the biggest bangs can come from some very small bucks!

VIRTUAL ORGANIZATIONS

- THE VIRTUAL ORGANIZATION GREW OUT OF PACKAGING LEAN MANUFACTURING, FLEXIBILITY AND AGILITY

- THE VIRTUAL ORGANIZATION RECOGNIZES THAT MOST PRODUCTS INVOLVE THE ASSEMBLY OF MANY PARTS MADE BY OTHER COMPANIES

- THE VIRTUAL ORGANIZATION ENABLES A GROUP OF COMPANIES TO FORM TOGETHER IN SOME FORM OF PARTNERSHIP IN ORDER TO BE COMPETITIVE IN MARKETS WHERE AGILITY IS REQUIRED OR CAN BE A COMPETITIVE ADVANTAGE

VIRTUAL ORGANIZATIONS (Continued)

- LEAN MANUFACTURING ANALYSES A COMPANY'S OPERATIONS, DETERMINES IT'S CORE COMPETENCIES AND SEPARATES THEM FROM OTHER "PERIPHERAL" JOBS. IT THEN CUTS THE CORE COMPETENCE STAFFING TO THE BONE AND OUTSOURCES THE PERIPHERAL JOBS TO OTHER COMPANIES, USUALLY ONES WITH SIGNIFICANTLY LOWER WAGE RATES

- THE VIRTUAL CORPORATION CAN DEVELOP SUPERIOR PRODUCTS DUE TO THE INVOLVEMENT OF THE BEST TECHNOLOGY IN THE TOTAL DESIGN

- IN MANY WAYS THE OFFSHORE PLATFORM INDUSTRY HAS USED A FORM OF VIRTUAL ORGANIZATIONS FOR YEARS

VIRTUAL ORGANIZATIONS (Continued)

- THE BIGGEST PROBLEM FOR COMPANIES THAT WANT To BECOME PART OF A VIRTUAL ORGANIZATION IS CHANGING FROM THE SUB-CONTRACTOR MENTALITY TO THE PARTNERSHIP

- A SUB-CONTRACTOR HAS MINIMAL RISK. A PARTNER SHARES COMPLETELY IN RISK

- THIS REQUIRES A TRUST BETWEEN THE PARTNERS THAT IS NOT GENERALLY FOUND BETWEEN SHIPBUILDERS AND THEIR SUPPLIERS OR SUB-CONTRACTORS

- FOR IT TO WORK IN U.S. NEW LEGAL VEHICLES WILL NEED To BE DEVELOPED

I

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CHARACTERISTICS OF A VIRTUAL ORGANIZATION

- MUST BE THE ULTIMATE IN ADAPTABILITY
- QUICK TO SEE AND CAPTURE OPPORTUNITIES
- OFFER EXCELLENCE IN CORE COMPETENCIES
- UTILIZE APPROPRIATE AND WORLD CLASS TECHNOLOGY
- MUST BE BORDERLESS OR SEAMLESS IN PERFORMANCE
- HIGH TRUST BETWEEN PARTNERS

THE VIRTUAL

CHARACTERISTICS OF A NEW CORPORATE MODEL

Today's joint ventures and strategic alliances may be an early glimpse of the business organization of the future: The Virtual Corporation. It's a temporary network of companies that come together quickly to exploit fast-changing opportunities. In a Virtual Corporation, companies can share costs, skills, and access to global markets, with each partner contributing what it's best at. Here are the key attributes of such an organization:

EXCELLENCE

Because each partner brings its "core competence" to the effort, it may be possible to create a "best-of-everything" organization. Every function and process could be world-class—something that no single company could achieve

TECHNOLOGY

Informational networks will help far-flung companies and entrepreneurs link up and work together from start to finish. The partnerships will be based on electronic contracts to keep the lawyers away and speed the linkups

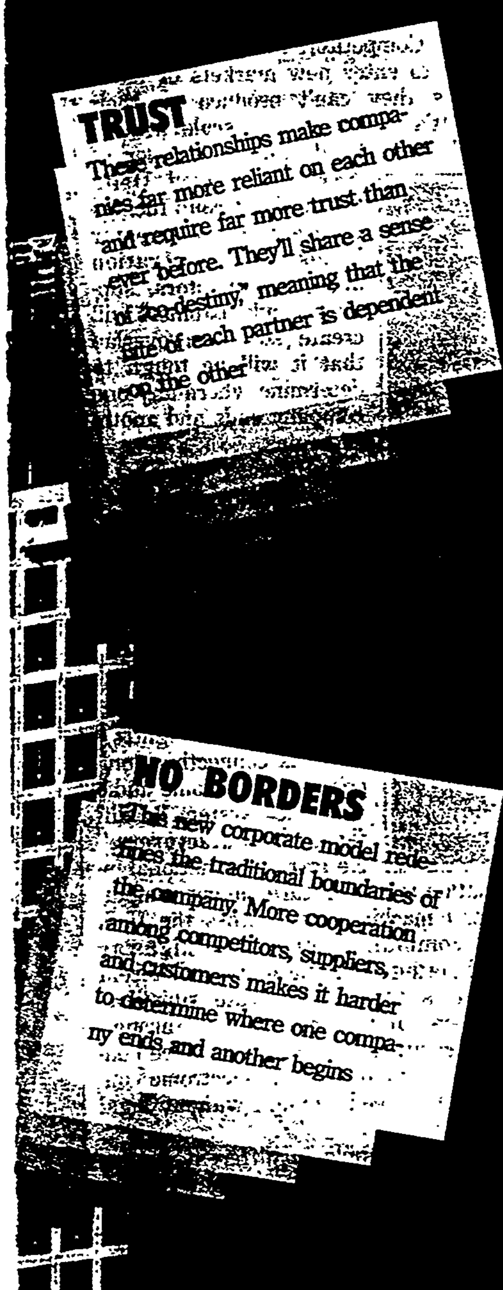
OPPORTUNISM

Partnerships will be less permanent, less formal, and more opportunistic. Companies will band together to meet a specific market opportunity and, more often than not, fall apart once the need evaporates

FREDERICK CHARLES

CORPORATION

THE COMPANY OF THE FUTURE WILL BE THE ULTIMATE IN ADAPTABILITY



You know the problems. They're the stuff of Management 101. If you run a big, complex company, you battle every day to get things done faster. If you're at the top of a small one, you often struggle to find the resources to make a difference.

In today's world of fast-moving global markets and fierce competition, the windows of opportunity are often frustratingly brief. Few companies boast the in-house expertise to quickly launch diverse and complex products in different markets.

Ever hear of the virtual corporation? Before you roll your eyes, think again. In the view of many leading business thinkers, what sounds like just another bit of management-consultant cyberspeak could well be the model for the American business organization in the years ahead.

The virtual corporation is a temporary network of independent companies—suppliers, customers, even erstwhile rivals—linked by information technology to share skills, costs, a access to one another's m kets. It will have neither c tral office nor organizati chart. It will have no hierarc no vertical integration.

Instead, proponents say t new, evolving corporate mo will be fluid and flexible group of collaborators t quickly unite to exploit a spe ic opportunity. Once the op tunity is met, the venture w more often than not, disba "It's not just a good idea," s Gerald Ross, co-founder Change Lab International, consulting firm in Greenwi Conn. "It's inevitable."

TIME STRETCHER. In the conce purest form, each compa that links up with others to c ate a virtual corporation will stripped to its essence. It contribute only what it rega as its "core competencies," buzz phrase for the key ca bilities of a company. It mix and match what it d best with the best of other c panies and entrepreneurs.

A manufacturer will ma

facture. while relying on a product-design outfit to decide what to make and on a marketing company to sell it. "Most companies put undue emphasis on owning, managing, and controlling every activity," says Richard C. Marcus, the former chief executive of retailer Neiman Marcus, who is now a partner in a consulting firm that models itself along virtual-corporation lines. "If something was worth doing, you did it yourself. But there's just not enough time in the day to manage everything anymore."

For proof that many companies are starting to feel the same way, look to the growing number of strategic alliances. American Telephone & Telegraph Co. used Japan's Marubeni Trading Co. to link up with Matsushita Electric Industrial Co. to jumpstart the production of its Safari notebook computer, designed by Henry Dreyfuss Associates. MCI Communications Corp. uses partnerships with as many as 100 companies to win major contracts with large customers. IBM, Apple Computer, and Motorola are using an interfirm alliance to develop an operating system and microprocessor for a new generation of computers.

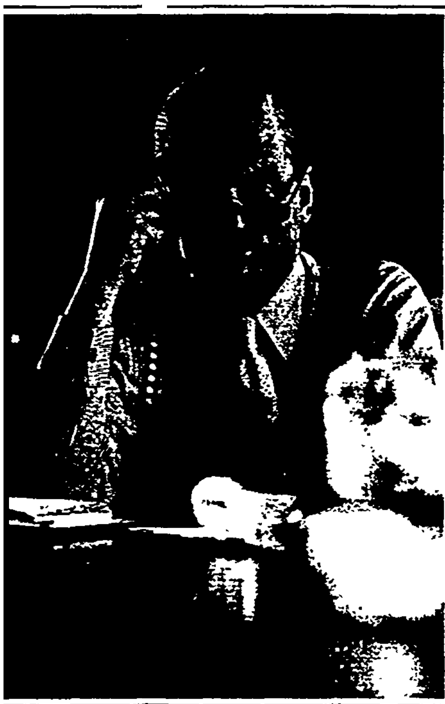
EARLY GLIMPSE. Partnering-the key attribute of the virtual corporation-will assume even *greater* importance, says James R. Houghton, chairman of coming Inc. Corning may be the most successful U.S. company at putting together alliances. Its 19 partnerships, accounting for nearly 13% of earnings last year, have let the company develop and sell new products faster, providing size and power without the bulk. "More companies are waking up to the fact that alliances are critical to the future." Houzhton says. 'Technologies are changing so fast that nobody can do it all alone anymore."

But today's joint ventures are little more than an early glimpse of the highly adaptable, opportunistic structure of the future. "When we talk about virtual corporations today, we're mainly talking about alliances and outstanding agreements: says John Sculley, chairman of Apple Computer Inc. "Ten or 20 years from now, you'll see an explosion of entrepreneurial industries and companies that will essentially form the real virtual corporations. Tens of thousands of virtual organizations may come out of this."

The virtual corporation may now exist mainly in the imaginations of a few business thinkers and theorists (page 103), but similar structures have long characterized several industries. In businesses as diverse as movie making and construction, companies have come together for years for specific projects, only to dissolve once the task is done. The leveraged-buyout firm of Kohlberg Kravis Roberts & Co. forms virtual-style combinations when it assembles lawyers, accountants, and investment bankers to do a specific deal.

What's different now is that large corporations have begun using elements of the virtual concept to gain access to new markets or technologies. Apple Computer's long-standing strategy of partnering is a key reason the company's revenues per employee, at $437,100, are nearly four times those of competitor Digital Equipment Corp. and more than twice those of IBM. Lacking the capacity to produce its entire line of PowerBook notebooks, for example, Apple turned to Sony Corp. in 1991 to manufacture the least-expensive version. It was an obvious pairing, melding Apple's easy-to-use software with Sony's manufacturing skills in miniaturization. A year later, after selling more than 100,000 Sony-made models, Apple ended its agreement

The linkage served its purpose to get an entry-level product out swiftly. Similarly, a small company, TelePad Corp. of Reston, Vs., is using collaborations with more than two dozen partners and sup pliers to bring its new pen-based computer to market.



'More companies are waking up to the fact that alliances are critical to the future'

JAMES R. HOUGHTON
CHAIRMAN, CORNING

If it becomes widespread. the virtual model could become th-e most important organizational innovation since the 1920s. That was when Pierre S. Du Pent and Alfred P. Sloan developed the principle of decentralization to organize giant, complex corporations. Even the spate of corporate downsizings in the past decade has failed to break the vertical chains of command typical in most large companies. Massive layoffs of middle managers have led to fewer layers of manage ment but have left essentially the same organizational structures.

SUPERHIGHWAY. Already, though, joint ventures and strategic alliances are blurring the traditional hierarchies and boundaries that characterize this largely obsolete model. Customers are helping to create and develop new products and services. Competitors are embracing one another to enter new markets or make products they can't produce on their own.. "It's a way to gain scale without mass," says David Nadler, founder of New York-based Delta Consulting Group Inc. Ultimately, these greater levels of cooperation among competitors, sup pliers, and customers will create so much overlap that it will be tough to determine where any one company ends and another begins.

Technology will play a central role in the development of the virtual corporation. Roger N. Nagel, operations director for Lehigh University's Iacocca Institute, envisions a world in which technology could make the creation of virtual enterprises "as straightforward as connecting components for a home audio and video system by different manufacturers." He foresees a national information infrastructure linking computers and machine tools across the U.S. This communications superhighway would permit far-flung units of different companies to quickly locate suppliers, designers, and manufacturers through an information clearinghouse. Once connected, they would sign "electronic contracts" to speed linkups without legal headaches.

Teams of people in different companies would routinely work together, concurrently rather than sequentially, via computer networks in real time. Artificial-intelligence systems and sensing devices would connect engineers directly to

the, production line. "Such confederations can be the American answer to the Japanese *keiretsu,* but a more powerful and flexible version," believes Nagel.

If power and flexibility are the obvious benefits of the virtual corporation, the model has some real risks, too. For starters, a company joining such a network loses control of the functions it cedes to its partners-who may drop the ball. Proprietary information or technology may escape. And the structure will pose stiff new challenges for managers, who must learn to build trust with outsiders and manage beyond their own walls.

Still others are wary of the concept because it conjures up the idea of the hollow corporation, the term coined to describe companies that have bolstered profits by abandoning manufacturing and out-sourcing production to plants in low-wage countries. Much of the thinking about the virtual corporation, however, comes from experts at the Iacocca Institute who have examined the decline of U.S. manufacturing. They believe the idea-coupled with computer-aided design and flexiile manufacturing-could keep jobs in the U.S. In their view, rapidly formed virtual corporations composed of the best of everything will have the competitive advantage.

'Ten or 20 y
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you'll see a
explosion o
entreprene
industries a
companies'

JOHN SCULLEY
CHAIRMAN, APP

'ROBUST.' A growing number of company chiefs agree. One is James C. Morgan, chief executive of Applied Materials Inc., which makes the equipment to manufacture semiconductors. Applied's success is baaed on a collaborative web of suppliers and customers. Each partner specializes in doing part of a system very well, so Applied doesn't have to do everything well. "It's easier to manage a bigger business if others are managing pieces for you," explains Morgan.

Many large corporations are using the virtual concept to broaden their offerings to customers or produce sophisticated products less expensively. MC1, the long-distance telephone company, has allied itself with an array of partners to offer customers "one+stop shopping" for all their communications needs, including helping customers finance their equipment purchases. "Our partnerships make us a more efficient competitor with a more robust set of product offerings," says Daniel F. Akerson, MCI's preaident.

A central part of MCI'S strategy is to match its core competencies in network integration and software development with the strengths of other companies making telecommunications equipment- The upshot: MCI doesn't have to spend its own capital to fund research and de velopment for hardware, leaving more resources for what it does best. MCI'S alliances allow it to offer customers a package of hardware and services baaed on the talents, skills, and resources of as many as 100 other companies. "If we had to do it on our own, it would cost us at least $300 million to $500 million a year in extra expenses: says Akeraon.

The virtual concept is also providing muscle and reach for some smaller com-

'I think it's a business buzz phrase that's meaningless. It's appetizing, but you get nothing out of it'

ANDREW GROVE
CHAIRMAN, INTEL

panies and entrepreneurs. A
most vocal advocates is Ron O
veteran of Xerox Corp. and A
puter who had an idea for a
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launched TelePad, which has
house design talent, a handfu
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computer was designed and co-
with GVO Inc., a prominent
design company in Palo Alto,
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advantage of the best effort of world-class partners to bring his product to market faster. Through more than two dozen collaborations, Oklewicz figures he is leveraging hia puny work force into more than a thousand highly trained staffers in design, engineering, manufacturing, and distribution. That Intel engineering team, for example, took only one week to solve problems Oklewicz believes his company would have spent as long as five months on. ‘We couldn’t hire this kind of talennt,” he says. “The hiring alone would have killed us.”

Of course, since TelePad is dependent on so many partners, it has ceded direct control of nearly all its operations. Does that bother the founder? Not at all. “I can go to sleep at night confident that IBM knows how to make this product, rather than worrying whether I made the right capital investment or hired the right people,” he says.

The idea has broad implications for service businesses, too. Consider InterSolve Group Inc., a Dallas-based management-consuking firm that consists largely of four partners. For any given assignment, InterSolve assembles "just-time” talent to solve problems or implement strat gies for clients that range from IBM to First Interstate Bancorp. Once a job is complete, the consulting team disbands. “One of the founding principles of our firm is that we would assemble and disassemble teams for work," says Edward R. McPherson. ‘We can bring the right talent to fit the assignment as opposed to using talent already in inventory. We don’t have to warehouse staff or specialists.”

InterSolve’s recently completed assignment for First Interstate, for example, saw the creation of four teams of 26 experta led by McPherson, who had met only one of the team members before the assignment. The group squeezed nearly $14 million in annual savings out of First Interstate’s back-room operations. “The advantage is you get specialists to work on your problerns says Hayden B. Watson, a senior vice-president at First Interstate. “AS long as you keep their activities coordinated, you’re going to get a lot more result for the money you spend.”

One of the big drawbacks to the virtual corportion B that it spells the loss of control over some operations. A partnership among Intel and Japanese companies NMB Semiconductor and Sharp to make products called flash memory chips shows the potential hazards. Worried that it couldn’t make the sizable investments to retain its lead in this important and growing market, Intel signed up the two Japanese companies to make flash chips for it. But NMB Semiconductor Co. had trouble getting its lime up and running last year just as the market was taking off.

As a result, Intel couldn’t get all the chips it could sell, and its share of the market dropped nearly 20 points in one year. Although he still believes in collaboration, Intel Chairman Andrew S. Grove is no fan of the virtual corporation. “I think it’s a business buzz phrase that’s meaningless: he says. “It’s appe tizing, but you get nothing out of it”

Critics also point to IBM’s experience in creating its first personal computer in 1981. To get into the market quickly, the computer giant relied on a pair of outsiders for the key technologies: Intel for microprocessors and Microsoft Corp. for the operating software. At first *IBM* won widespread praise for its unprecedented decision to develop a major product by forming partnerships with others outside its corporate walls. But the appreach also meant that IBM’S system wasn’t proprietary, and IBM soon found that it had created a market it could not control. Hundreds of clone makers emerged with lower prices and better products.

The more entangled companies become, the more chances there will be for them to stumble. Besides the technological hurdles of information highways and networks of partners that will make the virtual corporation a reality, the concept poses new challenges for management. Before companies can more routinely engage in collaboration, they must build a high level of trust in each other.

The current clutch of strategic alliances and joint ventures could help here, too, since they give companies a track record of cooperation. “People who think they can screw each other because we’re going to terminate six months later are missing the point because what we’re building is a web of trust and shared understandings,” says John Seely Brown. Brown heads Xerox’ Palo Alto Research Center, which recently developed new products jointly with Sun Microsystems Inc.

WIN-WIN **DEALS. The** virtual corporation will demand a different set of skills from all managers, proficiencies not unlike those that distinguish the best venture capitalists. They’ll have to build relationships, negotiate “win-win” deals, find the right partners with compatible goals and values, and protide the temporary organization with the right balance of freedom and control. That won’t be easy. “All of us are comfortable operating in a known environment” says John Vaughan, a divisional vice-president at M/A-Com, an electronic-components maker based in Burlington, Mass., which is joining with AT&T and others to create new products “All the politics are local, and all the management is personal. But this new model means you have to be more open in dealing with outsiders. To some people, that sounds like fun. To others, it will be hell.”

So common will collaborative work become that some gurus are already advocating the creation of a new corporate position. Lehigh’s Nagel suggests that companies appoint a “vice-president for external interactions” who would oversee the dozens or hundreds of linkups that he believes will exemplify the organization of tomorrow. Among other things, this corporate officer would monitor the oufflow of technology to make sure that the company doesn’t inadvertently lose the capability to compete.

A vice-president of virtuality? That would certainly be an irony-corporations may respond to this idea, so antithetical to structure and hierarchy, by creating a new slot for it in their hierarchical structures.

By John A. Byrne in New York, with Richard Brandt in San Francisco, Otis Port in New York, and bureau reports

A HANDBOOK FOR VIRTUAL MANAGERS

Today’s alliances have taught managers a few key lessons that should help when the virtual corporation emerges:

MARRY WELL Choose the right partners for the right reasons—because they are dependable, can be trusted, and offer the best products or services

PLAY FAIR Every link must offer a win-win opportunity for everyone, even if the outcome isn’t always successful. Partnerships must serve the interests of all parties

OFFER THE BEST AND BRIGHTEST Put your best people into these relationships. It’s the easiest way to tell your partners your link with them is important

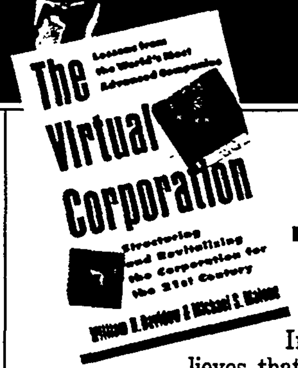
DEFINE OBJECTIVES When you ask the question, “what’s in it for me?” you should have a quick and ready answer. Know what you and your partners will be getting out of the virtual enterprise

BUILD A COMMON INFRASTRUCTURE Until networks and standards let corporations talk to each other across the street or across the ocean, information systems must at least communicate with current and potential partners

DATA: BOOZ ALLEN & HAMILTON INC

THE FUTURISTS WHO FATHERED THE IDEAS

Like victory, every good idea boasts many fathers. So it is with the virtual corporation. These days, a whole cadre of management thinkers lays claim to the term, and to each of them it means something slightly different.



MALONE AND DAVIDOW: IF COMPANIES FAIL TO ADAPT, THE U. S. IS DOOMED

To Jan Hopland, a Digital Equipment (hp. executive who probably coined the phrase, it describes an enterprise that can marshal more resources than it currently has on its own, using collabb rations both inside and outside its boundaries.

To Roger N. Nagel, a management guru who has crisscrossed the country giving about 50 presentations on the idea in the past 12 months, it largely means using technology to execute a wide array of temporary alliances with others in order to grasp specific market opportunities.

To William H. Davidow and Michael S. Malone. authors of The *Virtual Corporation, the* phrase is a catchall that encompasses a slew of management buzzwords and ideas from empowerment to just-in-time inventory
1. techniques. Indeed, the pair have so broadened the term "virtual" that it virtually means "virtuous."

APOSTLES. Whatever the precise definition, all these business futurists, and several others, agree on one thing The virtual corporation is the management model of 'tomorrow. With business becoming more global and more complex every day, many more partnerships are likely to emerge among companies and entrepreneurs.

LEHIGH'S NAGEL

In their collective view, today's joint ventures, strategic alliances, and outsourcing represent only the first trickle of what will he come a torrent of spontaneous partnerships. These will be aided by high-speed communications networks, common standards for swap ping design drawings and other work-in-progress, and informational data bases that will make it easier for companies to locate partners.

The virtual corporation's apostles are hardly shy about assessing the import of their notion. Nagel, operations director of Lehigh University's Iacocca **Institute, believes that a company's** desirability as a partner "will be a strategic requirement to remaining competitive." Davidow, *a Silicon* Valley venture capitalist, maintains that the U.S. "will be a post-industrial version of a developing country" if it fails to be a leader in forming virtual corporations by the year 2015.

Why virtual The term has its Or'-gins in the computer industry-but not as you might think, in the phrase "virtual reality." Instead, it derives from the early days of computing when the term "virtual memory" described a way of making a computer act as if it had more storage capacity than it really possessed. The virtual corporation will seem to be a single entity with vast capabilities but will really be the result of numerous collaborations assembled only when *they're* needed.

Hopland, who plots strategy for DEC'S information-technology business, began using the term "virtual enterprise" about five years ago when he was a member **of a B-school research team exploring** management changes in the 1990s. "It was clear we were entering an age in which organisations would spring up overnight and would have to form and reform relationships to survive," says Hopland." 'Virtual' had the technology metaphor. It was real, wasn't quite real."

Managers eager tc about what's virtua what isn't are unlikely much help from Da and Malone's book, pu last October. The pa the term so broadl their book reads li overview of manag trends—everything customer focus to total ty management. No r Malone says he now calls from company who are so enthusiastic about th that they want to transform thei organizations into virtual corpor

STEREOTYPES. That will be easie than done. Despite all the talk c technology will facilitate the corporation, there are some olc ioned obstacles to overcome. Fo era, changes in antitrust policy a tellectual-property laws ma necessary to spur cooperation a companies.

DEC'S HOPLAN

Those recommendations are among a series that emerged from a 1991 study by a task force at Lehigh co-chaired by Nagel and Richard K. Dove, an Oakland (Calif.) consultant. A former executive at International Harvester Co. and an expert in manufac**turing systems, Nagel also ma that executives will have to against a couple of "perr stereotypes."**

The first of these is the tende managers to devalue work perf by outsiders. The second is t American notion that doing som alone is superior to doing it as a group. "Companies have to stand the value of sharing resou make the idea work," says Nag their part, Nagel and his fellow ers are generally happy to crec another for their respective co tions. So here's one example, at of management gurus practicing they preach.

By John A. Byrne in Ne

Four key elements of Agile Shipbuilding:

Four key elements of agile shipbuilding are:
1. Enriching the customer
2. Cooperating to enhance competitiveness
3. Organizing to master change /uncertainty
4. Leveraging people and information

Each of these four elements is explained in brief in the following paragraphs.

1. **Enrich the customer**

An agile company in the shipbuilding value adding chain is one that is perceived by its customers as enriching ***them in*** a significant way. The products and services of an agile shipbuilder /component supplier are perceived by its customers as solutions to their, individual, problems. The package of goods and services that the customers buy are only means of implementing these solutions. The solutions are what the customers are paying for. The price these customers are willing to pay is a function of the perceived value of the solution p0rovided. This creates new marketing strategies and opportunities for shipyards to consider, and demands a reconceptualization of what a shipyard actually sells.

2. **Cooperate to enhance competitiveness:**

Cooperation, internally and with other companies in the shipbuilding value adding chain, is an agile shipbuilder's operational strategy of first choice. The end is bringing agile transportation solutions (ships) to market as rapidly and as cost effectively as possible. One strategy for achieving this is to utilize existing, most efficient resources regardless of where they are located and who owns them. Cross-functional teams, empowerment, reengineering, virtual companies and partnerships even with direct competitors are all means employed by agile shipbuilders to leverage resources through cooperation.

3. Organize to master change /uncertainty:

An agile shipbuilding company is organized in a way that allows it to thrive on change and uncertainty. It allows rapid reconfiguration of human and physical resources. There is no single right structure or no single right size. The goal of very rapid concept-to-cash time (or, world class design and build time) implies innovative, flexible organization structures that enable rapid decision making by distributing managerial authority. Personnel who are motivated and knowledgeable enough to convert change and uncertainty into new opportunities for company growth are thereby empowered to do so, routinely and rapidly.

4. Leverage people and information:

In an agile company, 'top management nurtures an entrepreneurial environment that. leverages the impact of people and information on operations. People- what they know, the initiative they show, the skills they posses, and information- are the diffrentiators among shipyards. Therefore, lifelong workforce education and training is integral to agile shipbuilding operations. It constitutes an investment in future prosperity, and not a cost to be assigned to current overhead expenses.

Shipbuilding Value Adding Chain (VAC):

Every firm is a collection of activities that are peformed to design, produce, market, deliver and support its products and services. These activities can be represented in the form of a chain. Every firm also procures at least some products (raw materials, components) and services from other firms (suppliers). These suppliers in turn procure some products and services from their suppliers. The same applies upstream to customers of each firm. In any industry, chains of organizations and activities that add majority of the value can be easily identified. These are called value adding chains (referred as VAC) . From a shipyard's perspective, a typical value adding chain would comprise of owner /operator, design agent, finance provider, yard, classification agency and major suppliers (such as engine, electrical, HVAC, etc.).

Evolving dynamics of a generic value adding chain in an agile environment:

In a traditional environment of mass production, members of a value adding chain (departments within a company, as well as companies within a chain) were decoupled and insulated from each other. Warehouses separated factories, inventories insulated processes, and processes isolated products. This system was managed by managing inventory and was measured by product focused metrics (cost /product, units /hr, etc.). Naturally, this arrangement was static, or, capable of only a slow change.

In the emerging agile environment, the members of a value adding chain are getting increasingly coupled. In many industries, notably auto, after tearing down bureaucratic, interdepartmental walls and integrating processes within a company, the action has moved to tearing down artificial barriers. between companies and integrating the processes within a value adding chain. In static world of slow change, this type of coupling leads to 'Lean Manufacturing' paradigm. However, as the pace of change in the market place quickens, the technological advances gain exponential momentum and customer expectations follow the suite, the couplings within the value adding chain become dynamic, or, capable of quick change. Factories and processes become dependent on each other, management must manage by managing processes and managing processes together, and measure by process focused and not product focused metrics.

In a typical mass production world, the production resources define the product which leads to a marketing plan to reach the customer. This can be depicted as follows:

Production resources → **Product** → **Marketing** → **Customer**

In the world of agile competition, the customer works with a team which pulls in resources from a virtual organization to create the customized solution.

Solution ← **Resources** ← **Team** ← **Customer**

In this new world,

- a **product** becomes a **platform,**
- a **customer** becomes a **subscriber,**
- a **supplier** becomes an **associate,**
- a sale becomes a **continuing transaction,**
- the **supplier** provides an **enriching, total solution;** and
- **Reward is** by **customer-perceived value.**

Need for a value adding chain synergy enabling infrastructure for the industry:

It is clear that the traditional industry infrastructure is no longer adequate or appropriate to successfully compete in this new, global market place. Each member of the shipbuilding value adding chain-owner/operator, financier, shipyard, design agent, classification agency, and major suppliers needs to invest in and deploy new tools, systems, and procedures to co-exist, co-operate and compete in an agile world.

The following pages of this report outlines items that need most and immediate attention. Dealing with the items in this list will automatically address the infrastructure requirements of an agile shipbuilding industry.

For each particular order, different firms within the shipbuilding industry will come together to form a value adding chain specific to that order. For the next order, the membership of the value adding chain may or may not be the same. To achieve a world class performance for every contract, a value adding chain synergy enabling base infrastructure, common across the industry, and mutually shared and accessed by all, is required. This infrastructure will allow every value adding chain to seamlessly form, function and dissolve in the least amount of time. The key elements of this infrastructure transcend beyond specific orders and specific firms. These elements must be viewed as a pre-requisite, a set of key characteristics that must be in place and key conditions that must be met in order for any company to exist and function in an agile US shipbuilding industry of the 21 st century.

Key **elements of the infrastructure:**

A progressive mind set: People of all levels, all functions, from all firms in the industry must share a mind set of mutual trust, open information sharing and teaming. Also, a good understanding of core competencies, zero tolerance for waste and rework of any kind, and an optimistic, 'can-do' spirit, at the management level will help. This mind can be cultivated over time only through concerted, persistent efforts in training and via teamwork.

Partnering enabling systems: In order to enable various companies to rapidly form some sort of partnership and closely work together to integrated the value adding chain, some legal, accounting and other types of standards and procedures must be in place.

Networked information systems: In order to utilize synergy of the value adding chain, people must be able to and empowered to communicate with each other, irrespective of who they work for. All companies must have access to networked communication systems, and must routinely exchange data in mutually compatible digital formats on a real time basis.

Product and process design and simulation tools: Another key element of rapid concept to cash cycle is the use of key enabling technologies. These include 3-D modeling, CAD/CAM, design based simulation and many other. Such tools need to be commonly available and accessible not only to a select few but to all members of the value adding chain.

A **structured, electronic knowledge base:** Compared to global competition, the US shipbuilding industry is lagging in commercial experience. Various members of the industry have been making serious individual efforts (benchmarking, foreign alliances, other) to overcome this handicap. It is possible to integrate all current and new knowledge in a structured, electronic data base and make it available, perhaps or a fee, to contributing companies or to those in need.

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MANAGING

CHANGE

UNDERSTANDING CHANGE

- IN THE PAST DECADE, 30 MILLION AMERICANS HAVE BEEN DISLOCATED BY RESTRUCTURING
- COMPANIES STILL ANTICIPATE THAT THEY WILL NEED TO REDUCE THEIR WORKFORCE BY 15% (LEAN AND MEAN)
- THE FORTUNE 500 COMPANIES HAVE AXED 3.2 MILLION JOBS SINCE 1980
- IN THE PAST 5 YEARS 12000 U.S. COMPANIES HAVE CHANGED OWNERSHIP
- ABOUT 70 % OF MERGERS FAIL

UNDERSTANDING CHANGE (Continued)

- MOST PEOPLE AND COMPANIES DO NOT WELCOME CHANGE
- CHANGE MUST BE MANAGED. IF LEFT TO ITSELF YOU DONT KNOW HOW IT WILL END AND YOU PROBABLY WILL NOT LIKE THE DESTINATION
- SOMETIMES CHANGE IS UNDERTAKEN ONLY WHEN SURVIVAL IS THREATENED
- OUTSIDE EVENTS USUALLY "TRIGGER" CHANGE, SUCH AS:
  - COMPETITORS MAKE A CHANGE
  - CUSTOMERS DEMANDS/EXPECTATIONS CHANGE
  - LEGISLATION CHANGES
  - HUMAN RESOURCE AVAILABILITY
  - EMPLOYEE EXPECTATIONS

UNDERSTANDING CHANGE (Continued)

- FOUR TYPES OF CHANGE

1. CHANGES IN TECHNOLOGY
   - INTRODUCTION OF CAD/CAM/CIM
   - NEW PRODUCTION PROCESSES
   - NEW FACILITIES
2. CHANGES IN PRODUCT
   - FROM MILITARY TO COMMERCIAL SHIPS
3. ADMINISTRATIVE CHANGES
   - ORGANIZATION STRUCTURE CHANGES
   - NEW MISSION STATEMENT
   - NEW PERFORMANCE APPRAISAL SYSTEM
4. CHANGES IN HUMAN RESOURCES
   - ORGANIZATIONAL BEHAVIOR INTERVENTIONS

Incremental Change	Radical Change
Continuous progression	Frame-breaking burst
Maintain equilibrium	Reach new equilibrium
Affect organizational part	Transform entire organization
Through normal structure and management processes	Create new structure and management
New technology	Breakthrough technology
Product improvement	New products create new markets

Source: Based on Alan D. Meyer, James B. Goes, and Geoffrey R. Brooks, "Organizations in Disequilibrium Environmenta and Industry Revolutions; in George Huber and William H. Glick (eds.) Organizational Charge and *Redesign, (New York* C University Press, 1992); and Harry S. Dent Jr.,"Growlh Through New Product Development; *SmallBusiness Reports,* Nov 1990,30-40.

Transparency 93 (Exhibit 8.1)

Incremental Versus Radical Change

BARRIERS TO CHANGE

- MANAGEMENTS INABILITY TO RECOGNIZE NEED *FOR* CHANGE
- MANAGEMENTS INABILITY TO RECOGNIZE BENEFITS
- LACK OF COORDINATION AND COOPERATION
- RISK SEEN TO BE TOO HIGH
- PERSONAL RESISTANCE TO CHANGE

WHY PEOPLE RESIST CHANGE

- PAROCHIAL SELF-INTEREST
- MISUNDERSTANDING
- FEAR OF THE UNKNOWN - FEAR OF FAILURE
- DIFFERENT ASSESSMENT OF NEED
- LACK OF TRUST BETWEEN THEM AND MANAGEMENT
- THREAT TO JOB SECURITY
- INERTIA - COMFORT WITH CURRENT SITUATION

Table 15-1: Methods for Reducing Resistance to Change

Approach	Situational Use	Advantages	Drawbacks
Education + Communication	Where there is a lack of information or inaccurate information and analysis.	Once persuaded, people often will help with the implementation of the change.	Can be very time-consuming if many people are involved.
Participation + Involvement	Where the initiators do not have all the information they need to design the change, and where others have considerable power to resist.	People who participate will be commited to implanting change, and any relevant information they have will be integrated into the change plan.	Can be very time-consuming if participators design an inappropriate change.
Facilitation + Support	Where people are resisting because of adjustment problems.	No other approach works as well with adjustment problems.	Can be time-consuming, expensive, and still fail.
Negotiation + Agreement	Where someone or some group will clearly lose out in a change, and where that group has considerable power to resist.	Sometimes it is a relatively easy way to avoid major resistance.	Can be too expensive in many cases if it alerts others to negotiate for compliance.
	where er tactics will work or are to expensive.	It can be-relatively quick and inexpensive solution [illegible]	an lead to future
E—licit + Implicit Coercion	Where speed is essential, and the change initiators possess considerable power.	It is speedy and can overcome any kind of resistance.	people angry at the

Source: Reprinted by permission of the Harvard Business Review. An exhibit from "Choosing Strategies for Change" by John P. Kotter and Leonard A. Schlesinger, March/April 1979.

HOW TO INCREASE CHANCE OF SUCCESS

- PLAN AND MANAGE THE CHANGE
- COMMUNICATE NEED FOR CHANGE BEFORE IMPLEMENTING ANY CHANGES
- MINIMIZE THE NEGATIVES AND MAXIMIZE THE POSITIVES
- INVOLVE THE PEOPLE WHO WILL BE IMPACTED BY THE CHANGE IN THE CHANGE PLANNING AND PROCESS
- USE CHANGE TEAMS
- PUT A RESPECTED MANAGER IN CHARGE OF THE CHANGE AND BUILD TRUST
- MAKE SURE YOU DO NOT DESTROY TRUST BY STUPID ACTIONS
- MAINTAIN PERCEIVED FAIRNESS IN DEALING WITH ALL EMPLOYEES
- VISIBLY REWARD THOSE WHO SUPPORT THE CHANGE

I. PREPARATION

Before the change, whenever possible, follow these steps:

- ❑ **Prepare your employees.** Let them know what is **happening ahead of time.** Telling them too far ahead of time is not always better (for example, telling people 8 months before a change only leaves time for anxiety to buildup).

- ❑ **Describe the change as completely as YOU can.How do you see the change affecting** individual employees and the work group as a whole? Identify who will be most affected and approach them first.

- ❑ Research **what happened during the last change. Does your group have a positive history of their ability to manage change,** or was the last change **traumatic? Learn** from past experience and let this background influence your current actions.

- ❑ **Assess the organizational readiness of your am. Are they ready to undertake a change? An organization** or group that isn't mentally and emotionally prepared will tend to stay in denial, rather than accept the change and move on.

- ❑ **Don't make additional changes that aren't critical.** People **need all the** stability they can get during change. Don't change the payroll dates, the working hours or cafeteria procedures when you are making large-scale organizational changes. Change the most important things one at a time.

IV. IMPLEMENTATION

Take clear, flexible action to accomplish these goals:

- ☐ **Provide appropriate training in new skills and coaching in new values and behaviors.**
- ☐ **Encourage self-management. Inform each person that** he or she is accountable for some aspect of the change
- ☐ **Give more feedback than usual to ensure that people always know where they stand.**
- ☐ **Allow for resistance. Help people let goof the "old." Prepare to help those** having special difficulty making the **adjustment.**
- ☐ **Give people a chance to step back and take *a* look at what is going** on. Keep asking, "Is the change working the way we want it to?".
- ☐ **Encourage people to think and act creatively.**
- ☐ **Look for any opportunity created by the change.**
- ☐ **Allow for withdrawal and return of people who are temporarily resistant. Don't cross off people as irretrievable.**
- ☐ **Collaborate. Build bridges from your work group to other work groups. L for** opportunities to interface your activities.
- ☐ **Monitor the change process. Conduct surveys to find** out **how employees are** responding to the change.

V. REWARD

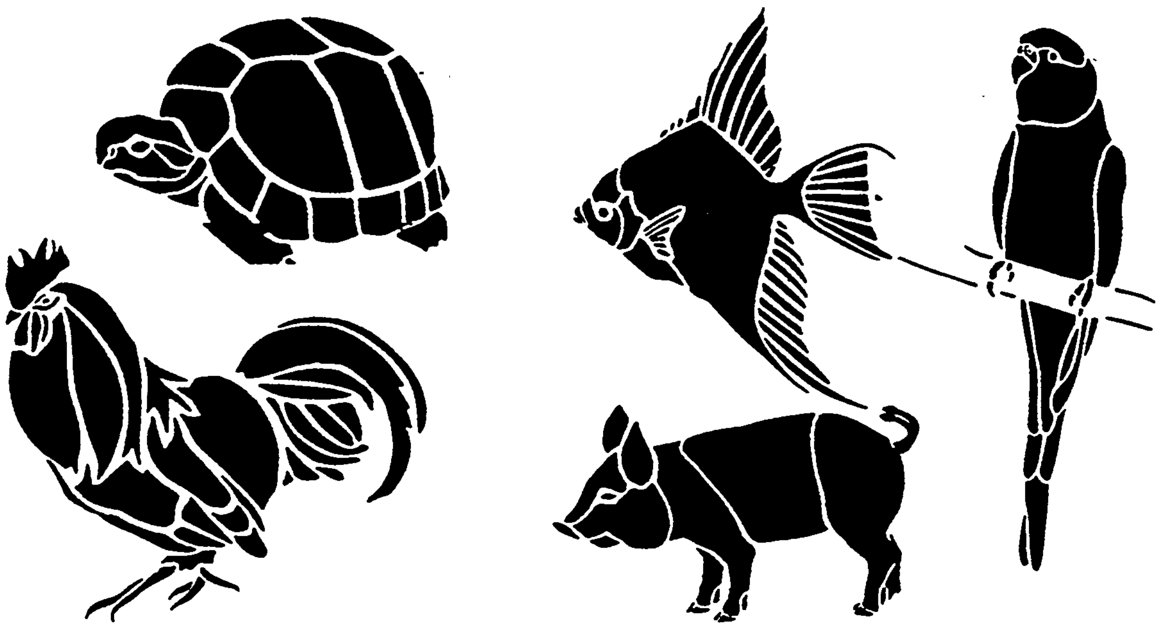
Share the gains:

- ☐ **Create incentives for special effort. Celebrate those who lead the change. Give one-time bonuses to groups who have come through the change smoothly.**
- ☐ **Celebrate by creating public displays that acknowledge groups and individuals who have helped make things happen.**

HANDOUT 79-1

DINOSAUR BRAINS

Directions: **Select any one of the following figures and use it to describe your basic mindset or paradigm as far os change is concerned.** To which animal would YOU compare your thing and why? If **you prefer, you can describe your manoger basic mindset toward change.** (YOU need not reveal Which mindset you are de **scribing-yours or the boss's.)**



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HANDOUT 17-1

THE FEAR FACTOR

Eliminating fear is obviously easier said than **done. But identifying how the fear makes us feel and is the circumstances that prompt a certain kind of fear-this is fairly easy to do. From such understanding, ore born "feelings" that move us away from fear and into wisdom.**

Look at the following types of fear. For each, think of a work related circumstance that can ev kind of fear. If possible, think of one thing that can be done to improve the circumstance. Use .Pers periences *or* **hypothetical ones.**

1. ______________________________
2. **Consternation.** ______________________________
3. Wo ______________________________
4. **Anxiety** ______________________________
5. **Dread** ______________________________
6. **Nervousness** ______________________________
7. **Revulsion** ______________________________
8. **Dismay** ______________________________
9. **Awe** ______________________________
10. **Hesltatlon** ______________________________

MANAGING THE HUMAN SIDE OF CHAN

ROSABETH *MOSS* **KANTER**

This is a time of historically unprecedented change for most corporations. The auto and steel industries are in turmoil because of the effects of foreign competition. Financial services are undergoing a revolution. Telecommunications companies are facing profound and dramatic changes because of the breakup of AT&T and greater competition from newly organized long-distance carriers. Health care organizations are under pressure to cut costs and improve services in the face of government regulation and the growth of for-profit hospital chains.

Change, and the need to manage it well, has always been with us. Business life is punctuated by necessary and expected changes: the introduction of new toothpastes, regular store remodellings, changes in information systems, reorganizations of the office staff, announcements of new benefits programs, radical rethinking of the fall product line, or a progression of new senior vice-presidents.

But as common as change is, the people who work in anh organization may still not like it. Each of those "routine" changes can be accompanied by tension, stress, squabbling, sabotage, turnover, subtle undermining, behind-the-scenes footdragging, work slowdowns, needless political battles,, and a drain on money and time-in short, symptoms of that ever-present bugaboo, resistance to change.

If even small and expected changes can be the occasion for decrease in organizational effectiveness, imagine the potential for disaster when organizations try to make big changes, such as developing a new corporate culture, restructuring the business to become more competitive, divesting losing operations and closing facilities, reshuffling product divisions to give them a market orientation, or moving into new sales channels.

Because the pace of change has speeded up, mastering change is increasingly a part of every manager's job. All managers need to know how to guide people through change so that they emerge at the other end with an effective organization. One important key is being able to analyze the reasons people resist change. Pinpointing the source of the resistance makes it possible to see what needs to be done to avoid resistance, or convert it into commitment to change.

As a consulting firm, Goodmeasure has worked with the change-related problems of over a hundred major organizations. We have distilled a list of the ten most common reasons managers encounter resistance to change, and tactics for dealing with each.

1. LOSS OF CONTROL

How people greet a change has to do with whether they feel in control of it or not. Change is exciting when it is done by us, threatening when it is done *to us.*

Most people want. and need. to. feel in control of the events around them. Indeed, behind the rise of participative management today is the notion that '"ownership" counts in getting commitment to actions, that if people have a chance to participate in decisions, they feel better about them. Even "involvement in details is better than noninvolvement. And the more choices thatt are left to people, the better they feel about the changes. If all actions are imposed upon them from outside, however, they- are-more likely to resist.

Thus, the more choices we can give people the better they'll feel about the change. But when they feel out of control and powerless, they are likely not only- to feel stress, but also to behave in defensive, territorial ways. I proposed in my 1977 *Men and Women of the Corporation* that, in organizations at least, it is *powerlessness* that "corrupts, " not power. When people fee] powerless, they behave in petty, territorial ways. They become rules-minded, and they are over-controlling, because they're trying to grab hold of some little piece of the world that they *do* control and then over-manage it to death. (One way to reassert control is to resist everyone else's new ideas.) People do funny things when they feel out of control, but giving people chances for involvement can help them feel

This article is excerpted from Kanter's new corporate education videotape, *Managing Change-The Human Dimension.* which is available from Goodmeasure, Inc., P. O. Box 3004, Cambridge, MA 02139.

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GE

Making employees feel good about change is a challenge for today's managers.

more committed to the change in question.

2. EXCESS UNCERTAINTY

A second reason people resist change is what I call the "Walking Off A Cliff Blindfolded Problem''—too much uncertainty. Simply not knowing enough about what the next step is going to be or feel like makes comfort impossible. If people don't know where the next step is going to take them, whether it is the organizational equivalent of off a cliff or under a train, change seems dangerous. Then they resist change, because they reason, "It's safer to stay with the devil you know than to commit yourself to the devil you donut. "

Managers who do not share enough information with their employees about exactly what is happening at every step of a change process, and about what they anticipate happening next, and about when more information will be *com*ing, make a mistake, because they're likely to meet with a great deal of resistance. Information counts in building commitment to a change. especially step-by-step scenarios with timetables and milestones. Dividing a big change into a number of small steps can help make it seem less risky and threatening. People can focus on one step at a time, but not a leap off the cliff; they know what to do next.

Change requires faith that the new way will indeed be the right way. If the leaders themselves do not appear convinced, then the rest of the people will not budge. Another key to resolving the discomfort of uncertainty is for leaders to demon-

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strate their commitment to change. Leaders have to be the first over the cliff if they want the people they manage to follow suit. Information. coupled with the leaders' actions to make change seem safer, can convert resistance to commitment.

3. SURPRISE, SURPRISE!

A think reason people resist change is the surprise factor. People are easily shocked by decisions or requests suddenly sprung on them without groundwork or preparation. Their first response to something totally new and unexpected, that they have not had time to prepare for mentally, is resistance.

Compantes frequently make this mistake when introducing organizational changes. They wait until all decisions are made, and then spring them on an unsuspecting population. One chemical company that has had to reorganize and frequently lay people off is particularly- prone to this error. A manager might come into work one day to find on her desk a list of people she is supposed to inform, immediately, that their jobs are changing or being eliminated. Consequently, that manager starts to wonder whether she is on somebody else's lisL and she feels so upset by the surprise that her commitment to the organization is reduced. The question, 'Why couldn't they trust me enough to even hint that this might happen?" is a legitimate one.

Decisions for change can be such a shock that there is no time to assimilate or absorb them, or see what might be good about those changes. All we can do is feel threatened and resist-defend against the new way or under tmine it.

Thus, it is important to not only provide employees with information to build a commitment to change, but also to arrange the timing of the information's release. Give people advance notice, a warning, and a chance to adjust their thinking.

4. THE "DIFFERENCE" EFFECT

A fourth reason people resist change is the effect of difference"—the fact that change requires people to become conscious of, and to question, familiar routines and habits.

A great deal of work in organizations is simply habitual. In fact, most of us could not function very well in life if we were not engaged in a high proportion of ""mindless" habitual activities-like turning right when you walk down the corridor to work, or handling certain forms, or attending certain meetings. Imagine what it would be like if, every day you went to work, your office was in an entirely different place and the furniture was rearnrtged. You would stumble around, have trouble finding things, feel uncomfortable, and need to expend an additional amount of physical and emotioml energy This would be exhausting and fattguing. Indeed, rapidly growing high-technology companies often present people with an approximation of this new-office-every-day nightmare, because the addition of new people and new tasks is ubiquitous, while established routines and habitual procedures are minimal. The overwork syndrome and "burn-out" phenomenon are accordingly common in the industry.

One analogy comes from my work on the introduction of a person who is different" (an "O") in a group formerly made up of only one kind of person (the "X's"), the theme of Goodmeasure's production, A Tale of "O." When a group of Xs has been accustomed to doing things a certain way, to having habits and modes of conversation and jokes that are unquestioned, they are threatened by the presence of a person who seems to require operating in a different way. The X's are likely to resist the introduction of the O, because the difference effect makes them start feeling self-conscious, requires that they question even the habitual things that they do, and demands that they think about behavior that used to be taken for granted. The extra effort required to "reprogram" the routines is what causes resistance to the change.

Thus, an important goal in managing change is to minimize or reduce the number of "differences" introduced by the change, leaving as. many habits and routines as possible in place. Sometimes managers think they should be doing just the opposite-changing everything else they can think of to symbolize that the core change is really happening. But commitment to change is more likely to occur when the change is not presented as a wild difference but rather as continuous with tradition. Roger Smith, the chairman of General Motors, launched what I consider one of the most revolutionary periods of change in the company.s history by invoking not revolution. but traddition .'l.m going to take this company back to the way Alfred Sloan intended it to be managed:"

Not only do many peopleneed or prefer fanuhar routines, the! also like familiar surroundings. Matntaining some familiar sights and sounds, the things that make people feel comfortable and at home, is ve~ important in. getting employees commitment to a change.

5. LOSS OF FACE

If accepting a change means admitting that the way things we done in the past was wrong, peop!e are certain to resist. Nobody fikes losing face or feeling embarrassed in front of their peers. But sometimes making a commitment to a new procedure, product, or program carries' with it the implicit assumption that the "old ways" must have been wrong, thereby putting alJ the adherents of the "old ways" in the uncomfortable position of either looking stupid for their past actions or being forced to defend them-and thereby arguing against any change.

The great sociologist Erving Goffrnan showed that people would go to great Iengths to save face, even engaging in actions contrary to their long-term interest to avoid ernbarassment.

1 have seen a number of new chief executives introduce future strategies in ways that "put down". the preceding strategies, thus making automatic enemies of the members of the group that had formulated and executed them. The rhetoric of their speeches implies that the new way gains strength only in contrast to the failures and flaws of the old way—a kind of Maoist "cultural revolution" mentality in business. "The way we've been managing is terrible," one CEO says routinely. He thus makes it hard for people who lived the old ways to shed them for the new, because to do so is to admit they must have been "terrible" before. While Mao got such confessions, businesses do not.

Instead, commitment to change is ensured when past actions are put in perspective-as the apparently right thing to do then, but now times are different. This way people do not lose face for changing just the opposite. They look strong and flexible.

BUILDING COMMITMENT TO CHANGE

- Allow room for participation in the planning of the change.
- Leave choices within the overall decision to change.
- Provide a clear picture of the change, a "vision" with details about the new state.
- Share information about change plans to the fullest extent possible.
- Divide a big Change into more manageable and familiar steps; let people take a small step first.
- Minimize surprises; give people advance warning about new requirements.
- Allow for digestion of change requests-a chance to become accustomed to the idea of change before making a commitment.
- Repeatedly demonstrate your own commitment to the change.
- Make standards and requirements clear-tell exactly what is expected of people in the change.
- Offer positive reinforcement for competence; let people know they can do it.
- Look for and reward pioneers, innovators, and early successes to serve as models.
- Help people find or feel compensated for the extra time and energy change requires.
- Avoid creating obvious "losers" from the change. (But if there are some, be honest with them-early on.)
- Allow expressions of nostalgia and grief for the past—then create excitement about the future.

—Rosabeth Moss Kanter and the staff of Goodmeasure, Inc.

They have been honored for what they accomplished under the old conditions, even if it is now time to change.

6. CONCERNS ABOUT FUTURE COMPETENCE

Sometimes people resist change because of personal concerns about their future ability to be effective after the change Can I do it? How will I do it? Will I make it under the new conditions? Do I have the skills to operate in a new way? These concerns may not be expressed out loud, but they can result in finding many reasons why change should be avoided.

In local telephone companies, employees have been told for years that they would be promoted for one set of reasons, and the workers had developed one set of skills and competencies. It is very threatening for many employees to be told that, all of a sudden, the new world demands a new set of competencies, a new set of more market-oriented entrepreneurial skills. Nobody likes to. look inadequate. And nobody, especially people who have been around a long time, wants to feel that he or she has to "'start over again" in order to feel competent in the organization.

It is essential, when managing a change, to make sure that people do feel competent, that there is sufficient education and training available so that people understand what is happening and know that they can master it—that they can indeed do what is needed. Positive reinforcement is even more important in managing change than it is in managing routine situations.

In addition to education and training, people also need a chance to practice the new skills or actions without feeling that they are being judged or that they are going to look foolish to them colleagues and peers. They need a chance to get comfortable with new routines or new ways of operating without feeling stupid because they have questions to ask. Unfortunately, many corporations I know have spent a lot of time making executives and managers feel stupid if they have questions: they're the ones that are supposed to have the answers.

We have to be sensitive enough in the management of change to make sure that nobody feels stupid, that everyone can ask questions, and that everybody has a chance to be a learner, to come to feel competent in the new ways.

7. RIPPLE EFFECTS

People may resist change for reasons connected to their own activities. Change does sometimes disrupt other kinds of plans or projects. or even personal and family activities that have nothing to do with the job, and anticipation of those disruptions causes resistance to change.

Changes inevitably send ripples beyond their intended impact. The ripples may also negate promises the organization has made. Plans or activities seemingly unrelated to the core of the change can be very important to people. Effective "change masters" are sensitive to the ripples changes cause. They look for the ripples and introduce the change with flexibility so that, for example, people who have children can finish out the school year before relocating, or managers who want to finish a pet project can do so, or departments can go through a transition period rather than facing an abrupt change. That kind of sensitivity helps get people on board and makes them feel committed, rather than resistant, to the change.

8. MORE WORK

One reasonable source of resistance to change is that change is simply more work. The effort it takes to manage things under routine circumstances needs to be multiplied when things are changing. Change requires more energy, more time, and greater mental preoccupation.

Members of project teams creating innovation put in a great deaf of overtime on their own, because of the demands-and the lure-of creating something new. During the breakup of the Bell System, many managers worked 60 or 70 hour weeks during the process, not seeing their families, simply because of the work involved in moving such a large system from one state to another. And the pattern is repeated in corporation after corporation.

Change does require above-and-beyond effort. It cannot be done

automatically, it cannot be done without extra effort, and it takes time. There is ample reason to resist change, if people do not want to put in the effort. They need support and compensation for the extra work of change in order to move from resistance to commitment.

Managers have options for providing that support. They can make sure that families are informed and understanding about the period of extra effort. They can make sure that people are given credit for the effort they are putting in and rewarded for the fact that they are working harder than ever before—rewards ranging from cash bonuses to special trips or celebrations. They can recognize that the extra effort is voluntary and not take it for granted, but thank people by providing recognition, as well as the additional support or facilities or comfort they need. While an employee is working harder, it certainly helps to know that your boss is acknowledging that extra effort and time.

RATE INCLUDES MANUAL ELEMENTS.

Change is never entirely negative: it's also a tremendous opportunity. But there's always some loss.

9. PAST RESENTMENTS

The ninth reason people- resist change is negative, but it is a reality of organizational life-those cobwebs of the past that get in the way of the future. Anyone who has ever had a gripe against the organization is likely to resist the organization telling them that they now have to do something new.

The conspiracy of silence, that uneasy truce possible as long as everything remains the same and people can avoid confrontations, is broken when you ask for change. Unresolved grievances from the past rise up to entangle and hamper the change effort. One new plant manager at Honeywell was surprised by resistance to a quality-of-work-life program, which he thought the workers would like because of the direct benefits to them. Then he discovered that the workers were still angry at management for failing to get them a quiet air-conditioning system despite years of complaints about summer noise levels in the factory. Until he listened to them and responded to their grievance, he could not get their commitment to his change plans.

Sweeping away the cobwebs of the past is sometimes a necessity for overcoming resistance to change. As long as they remain aggrieved, people will not want to go along with something we want. Going forward can thus mean first going back—listening to past resentments and repairing past rifts.

10. SOMETIMES THE THREAT IS REAL

The last reason people resist change is, in many ways, the most reasonable of all: Sometimes the threat posed by the change is a real one.

Sometimes a change does create winners and losers. Sometimes people do lose status, clout, or comfort because of the change. It would be naive to imagine otherwise. In fact, managing change well means recognizing its political realities.

The important thing here is to avoid pretense and false promises. If some people arc going to lose something. they should hear about it early. rather than worrying about it constantly and infecting others with their anxiety or antagonism. And if some people are going to be let go or moved elsewhere, it is more humane to do it fast.

We all know the relief that people feel. even people who are being told the worst, at finally knowing that the thing they have feared is true. Now they can go ahead and plan their life. Thus, if some people are threatened by change because of the realities of their situations, managers should not pretend this is not so. Instead, they should make a clean break or a clean cut—as the first step in change, rather than leaving it to the end.

Of course, we all lose something in change. even the winners. Even those of us who are exhilarated about the opportunity it represents, or who are choosing to participate in a new era that we think is going to be better for our careers, more productive and technologically exciting, as many of the changes in American corporations promise to be.

Change is never entirely negative: it is also a tremendous opportunity. But even in that opportunity there is some small loss. It can be a loss of the past, a loss of routines, comforts, and traditions that were important, maybe a loss of relationships that became very close over time. Things will not, in fact, be the same any more.

Thus, we all need a chance to let goof the past. to '"mourn" it. Rituals of parting help us say goodbye to the people we have been close to, rather than just letting those relationships slip away. "Memorial services, " "eulogies, " or events to honor the past help us let go. Unfortunately, those kinds of ceremonies and rituals are not legitimate in some companies. Instead, people are in one state, and the next day they have to move to another state without any acknowledgement of the loss that is involved. But things like goodbye parties or file-burning ceremonies or tacking up the company's history on bulletin boards are not just frills or luxuries; they are rituals that make it easier for people to move into the future because their loss is acknowledged and dealt with.

Resistance to change is not irrational it stems from good and understandable concerns. Managers who can analyze the sources of resistance are in the best position to invent the solutions to it—and to manage change smoothly and effectively.

There may be no skill more important for the challenging times

Rosabeth Moss Kanter is the author of the current management bestseller, The Change Masters: Innovation and Entrepreneurship in the American Corporation. She is also chairman of the board of Goodmeasure, Inc. and an advisor to many Fortune 500 companies. Kanter is currently on leave from Yale, where she is a professor of sociology and of organization and management in the School of Management.

(To order reprints see P. 32).

MANUAL METHODS

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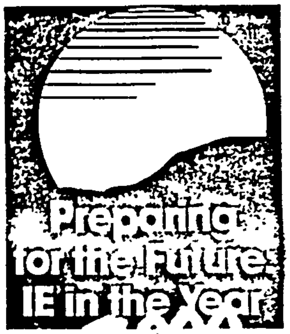
378. TRANSPORT STAGING BRACKET WITH (GROVE CRANE) AT TANK (OR WAY) CA
     PER STAGING BRACKET OFG: 3 02-FEB-82
       REPRESENTS ELAPSED TIME
      * REPRESENTS TRANSPORTING BRACKETS FROM...
      * ...BIN-1 TO BULKHEAD
      * DISTANCES FROM CRANE-REST TO BIN-1 AND..
      * ...FROM BIN-1 TO BULKHEAD ARE AVERAGE...
      * ...DISTANCES IN A CENTER TANK 98'X50'
      * MAXIMUM NUMBER OF BRKTS IN LIFT = 6
     C-OPER BEGINS AT CR-1

      1 TRANSPORT BRKT FROM BIN-1 USING CRANE WITH HOOK+SLING TO BULK
         BTWN BRKTS ) PLACE+ADJUST RETURN TO CR-1 F 1 / 6


381. TRANSPORT LADDERS WITH (GROVE CRANE) AT TANK CARPENTER
     PER LADDER OFG: 3 03-FEB-82
       REPRESENTS ELAPSED TIME
      * REPRESENTS TRANSPORTING LADDERS FROM....
      * ...LDR-PILE TO BULKHEAD
      * DISTANCES FROM CRANE-REST TO LDR-PILE...
      * ...AND FROM LDR-PILE TO BULKHEAD ARE....
      * ...AVERAGE DISTANCES IN A CENTER TANK...
      * ...98'X50'
      * MAXIMUM NUMBER OF LADDERS IN LIFT = 3
     C-OPER BEGINS AT CR-1

      1 TRANSPORT LADR FROM LDR-PILE USING CRANE WITH HOOK+SLING TO B
         ( AT. LDR ) PLACE+ADJUST RETURN TO CR-1 F 1 / 3
```



Can IEs Become Masters Of Change?

By D. Scott Sink, P.E.
Virginia Polytechnic Institute and State University

The term "change master" seems to have been coined by Rosabeth Moss Kanter, author of a best-selling book entitled: *The Change Masters: Innovation for Productivity in the American Corporation.* It is an interesting and timely term, and this outstanding book is filled with insights into critical challenges American managers face relative to managing complex organizations in the '80s and '90s. Kanter is a sociologist by training. Her book has been a bestseller.

In 1979, William T. Morris wrote and published a book entitled *Implementation Strategies for Industrial Engineers.* It also was an excellent book about change and how the IE can play a critical role in managing change. It received IIE's book of the year award. Morris is an industrial engineer by training. The book, unfortunately, was not a best seller, even among IEs.

My somewhat critical thesis in this article is that the IE profession is slowly being mastered by change. The number of IEs who have read *Change Masters* is probably deplorably few. Only approximately 700 copies of Morris's book were sold. Reading these books isn't going to make anyone a change master, but it is a start. Their popularity—or, apparently, lack of popularity—among IEs indicates to me that not many of us see change mastering as a role of our profession.

The number of practicing IEs who read anything about the behavioral sciences or management, from reputable sources, is I suspect very small. Seminar audiences I have polled in recent years have indicated a general unfamiliarity with motivational theories that are less than 30 or so years old. The IE student who is exposed to industrial psychology, sociology, organizational development, organizational behavior, or for that matter, one good course on management while in college is a rarity. The lack of exposure to and awareness of current motivation theories and techniques, a knowledge of which is fundamental to understanding how to manage change, clearly indicates to me a real lack of interest in and background for change mastering.

The IE profession has over the past ten years or so characterized itself using such bold statements as, "Changemasters of business and industry, industrial engineers are uniquely trained and experienced in management of the 'big picture'." The IE is described as "*the* systems integrator," "*the* productivity engineer," etc. I wish these were fair and valid claims. I believe the truth is the following:

- The profession of industrial engineering has evolved through at least three reasonably distinct stages that can be broadly labeled:
  - ☐ Scientific management.
  - ☐ Operations research.
  - ☐ Systems engineering.

I believe that, broadly speaking, these terms characterize periods in our profession's evolution and major focuses within these periods. I am not suggesting that scientific management and operations research are only a part of our past. Evolution in a discipline is a cumulative process of refining, adding, modifying, combining and enhancing tools, methodologies, techniques, concepts and theories associated with that discipline.

Note that a true management perspective is a part of our roots, but that it has slowly but surely almost disappeared from our present. The truth is that our discipline, for all practical purposes, ignores current, salient, pragmatic management issues. Our profession has developed good technological and quantitative technique balance, but we have extremely poor sociological, behavioral, organizational and qualitative balance. In *Megatrends* author John Naisbitt's terms, we have "high tech without high touch." You can't be a change master without both.

The business schools have systematically raided our curriculum. The undergraduate curricula in IE do not, I would argue, uniquely train the student to manage the "big picture." Most IEs are myopic, narrowly trained and oftentimes a little arrogant relative to their skills in comparison to the skills and capabilities of other disciplines. The bottom line is that I do not believe most IE students are uniquely trained to become change masters.

- The IE function in most American organizations is poorly postured and not particularly powerful, and there-

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Figure 1: Ten-Year Plan for Change in American Organizations

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MANUAL METHODS

TRANSPORT STANCHION WITH (GROVE CRANE) AT TANK CARPENTER
PER STANCHION OFG: 3 02-FEB-82
 REPRESENTS ELAPSED TIME
 * REPRESENTS TRANSPORTING STANCHION FROM..
 * ...BIN-2 TO BULKHEAD
 * DISTANCES FROM CRANE-REST TO BIN-2 AND..
 * ...FROM BIN-2 TO BULKHEAD ARE AVERAGE...
 * ...DISTANCES IN A CENTER TANK 98'X50'
 * MAXIMUM NUMBER OF STANCHIONS IN LIFT = 6
C-OPER BEGINS AT CR-1

 1 TRANSPORT STAN FROM BIN-2 USING CRANE WITH HOOK+SLING TO BULKHE
    BTWN BRKTS ) PLACE+ADJUST RETURN TO CR-1 F 1 / 6

TRANSPORT HANDRAIL WITH (GROVE CRANE) AT TANK CARPENTER
```

fore has tended not to play a very major role in strategy formulation for the critical socio-technical changes that are taking place. The IE function in most companies has not evolved beyond the role of efficiency expert, standards establisher and maintainer, methods analyst—the scientific management stage.

Many IE functions have not grown or evolved because of lack of leadership. Our discipline has an image problem internally and externally. We tend not to have a crystallized perception of who we are or what we can do.

IE managers, most critically, must have this crystallized vision if they are to lead the function within their organizations. I find IE departments in major US firms being managed by people who don't even have IE degrees. Management evidently has an image of what it wants IE to be and hires someone who will conform to that image. As a result, there is a tremendous disparity from company to company in terms of how the IE function is viewed and utilized.

I also do not believe that the practicing IE is experienced in the management of the big picture. Most practicing IEs, if they have IE degrees (many do not have formal degrees), carry with them to industry, business and government the same myopic, fragmented, highly disciplinary views of the world that academia presents to them. The IE function in America, in general, is not a change master function.

American business and industry face severe challenges in the '80s and '90s. Change, adaptability, responsiveness and flexibility will become key words. The competitive environment is and will continue to be dynamic, turbulent, risky and extremely challenging. Those organizations that can innovate in response to their environment will survive. Those that can't will not likely survive.

There is definitely a need for change masters, and the question to be addressed here is how the IE profession can begin to fulfill that needed role. We will begin by examining some major challenges facing American business and industry in the '80s and '90s.

Figure 1 depicts two orga tions, A and Z. The pyramid c left, organization A, represents ical American organization in ture, policy, procedures and cesses. We depict only sketchy lights of how this type of-orga tion is structured and functio probably looks and sounds a lo your organization.

The pyramid on the right, o zation Z, represents a fairly at American organization in stru policy, procedures and processe

Organization A was highly a priate and successful in the 194 the competitive environmen technology evolved in the '60 '70s, its structures and pra became less and less effective.

Organizations and industries fronted with stiff international petition were forced to deal wit reality first. Many recognize challenges but could not adapt ly enough.

The number of American nesses that can and will succes adapt is, unfortunately, much

Table 1: lE Roles Comparison

Traditional IE Roles	Change Master Roles
Expert, solution provider	Acceptant listener
Data gatherer	Structured group process provider
System designer	Teacher, skill developer
Problem-solver	Facilitator
Data analyst	Data gatherer
Technique application	Collaborator, team member
Challenger	Team leader, situational leader
Decision maker	Challenger
Consultant	Participative management system designer
	Catalyst
	Design team leader

han the number that will fail.

The stimuli driving this necessary change, evolution or, as some see it, revolution are primarily technology, world competition and world marketplaces, and underlying sociological changes in the character and composition of the American work force. Here are two examples I hope will convince you that these forces of change are major and must be dealt with in a proactive fashion.

Let me give you $100,000 to invest (long term) in company A or company Z (see Figure 1). Let's assume they are equivalent organizations (i.e., same size, same product, same competition, etc.) except for their obvious structural and management process differences.

The deal is that you and I will split the long term returns from this investment. Where will you put the investment? Most who are asked say company Z. Why? Typical responses are: it will outperform company A over the longer term: it will adapt and respond to challenges and opportunities more quickly; it has delegated planning, problem-solving and decision-making to the lowest appropriate levels; company A is reactive and company Z is proactive.

Hidden in the logic of these responses is an awareness, which I find very common among American unions, employees, staff and managers, that the world is changing and that our organizations must adapt and evolve. I believe we are aware of and understand the stimuli for change in the '80s and '90s. I am not sure that our management or the IE knows how to manage this change effectively.

How do we become an organization of the future? Many of our organizations have become factories of the '80s. They have bought the new technology. How do we move from being a factory of the '80s to being an organization of the '80s?

It has been suggested that if your competitive edge is only technology, it is not a comfortable one. Your competition can buy the new technology and install it rather quickly. However, if your competitive edge- is a well developed and integrated socio-technical system, an organization Z, that blends effective structure and management process with appropriate technology, this is a real competitive edge that can only be developed, not bought.

My second example is an actual case study of an organization that planned for and executed a change strategy designed to move it from a company A to a company Z. The organization manufactures integrated circuit chips. There are 2,700 employees (white and blue collar) in the plant.

In 1971, the plant began to plan for and develop a participative management process. From 1971-1975, the strategy or plan called for foundation laying, development, awareness, training and infra-structure building. The overall goal of the process is to involve all employees (management, staff and line workers) in *proactive* planning, problem-solving and decision making. Groups are expected to develop proposals for ideas for performance improvement.

The plant was broken down into approximately 360 groups of eight to 10 persons each. In 1977, six years after process initiation, the first proposals were solicited. In 1978.26,543 proposals were submitted. In 1979, 47,347 proposals were submitted. In the second half of 1980, 112,022 proposals were submitted and 98,347 (87.8%) were implemented.

The plant in this example is Japanese, but easily could have been German, or French, or American. This is our competition. These are the stimuli for change. If we donut manage change, we won't be around.

Change and change masters

Change is an inevitable and critical fact of life in the '80s and '90s. We see all kinds of organizations in the midst of numerous technological and management related interventions. Not many are well planned, but there at least is a lot of activity.

We know that change is often resisted because it is painful, threatening, uncertain, misunderstood, costly, different. We know that to manage change successfully, one must recognize that individuals, groups, organizations and even professions will probably.. need to progress or be moved through at least three stages that encompass the following:

- *Stage 1:* Awareness that there is a need to change, that there is pain, that there is cognitive dissonance.
- *Stage* 2: Willingness to change; knowledge of what to change; skills to change; and commitment to change.
- *Stage* 3. Execution of change paying the price of effective implementation.

A change master has to understand these stages and to develop the interpersonal skills necessary to handle them. Morris addresses this in presenting his phases of client change (chapter 2, pages 35-58). Kanter speaks to this concern throughout

her book; but also specifically in chapter 2, pages 37-65. The bottom line for any kind of change or intervention, even—indeed, perhaps most critically-the most capital intensive, is managing the behavior necessary to support the change.

Morris suggests that professional "students" (i.e., change masters) progress through three distinct stages of development:

1.) *The analytical* stage—in which we learn basic facts, theories, techniques, models and approaches. This stage relative to the technical si our profession *occurs* in high sc and college. Relative to behav and management issues it r takes place for most IEs, and h lies a major roadblock we must come if we are to become effe change masters. Without a s behavioral science foundation *cannot* become a successful ch master.

2.) *The problem-solving stage* which we take basic knowledge, niques, theories, etc., and apply in a complex, imperfect, hi uncertain and dynamic world. stage begins, for most IEs, with senior design project and should tinue as their careers progress i "real world." However, again quality of problem-solving is h dependent upon the balance o able to bring to the behavioral technical sides of problems. W technically sound solutions that be or aren't implemented effecti We see politically nonastute IE to force good solutions on unwi clients.

3.) *The client-centered* stage- which we begin to realize tha effective implementation of a c sion or solution to a problem dep upon two things: (a) the quali the decision or solution, and (b acceptance of the decision or sol by the people who will have to ir ment it.

successful change ma progress through these stages v disciplined, aggressive formal informal educational process. I IEs leave college with a relati weak foundation for entering progressing through stages 2 ar Most practicing IEs do mair their technical skills (whic enough of a challenge today), neglect development of stages 2 3.

Table 1 depicts traditional IE and compares and contrasts t with change master roles. We

Table 2: Expertise and Techniques

Traditional IE Areas of Expertise and Techniques	IE Areas of Expertise and Techniques for the '80s and '90s
l	Performance and productivity measurement
l MANUAL	Operations analysis, input/output analysis, path-goal theory application
l . RFMNUF STAGTNG PI ANK O	Socio-technical systems design
plus l' REPRESENTS ELAPSED T * REPRESENT REMOVING * ...-PILE ON TANKTOP * ...MANHOLE). * MAXIMUM NUMBER OF B	Management support systems design, development, and facilitation
l CARP-3 BEGINS AT MATL-	Capital productivity management
l 1 CARP-3 GET+SLIDE BO 2 WINCH-OPER PUSH WIN 3 WINCH-OPER LOOSEN (	Manufacturing systems management, productivity management
l ARM-STROKES USING 4 WINCH-OPER THROW CA 5 CARP-3 GET+MANIPULA	Quality management (total)
l BOARDS) (ALLOW F 6 WINCH-OPER PUSH WIN 7 WINCH-OPER PUSH WIN	Strategic planning, action planning and effective implementation of productivity management processes and efforts
1. REMOVE LADDER ON (LADD CARPENTER PFR LADDER REQ: 3 OR-F	Corporate finance, cost accounting, organizational development, industrial psychology, sociology, organizational behavior, design

some overlain but also some distinct differences in roles. The end results or goals don't change significantly, but the process by which the professional (IE/change master) achieves the result does change.

Change master skills include the ability to diagnose a given system or situation and to develop a response that is appropriate to that particular situation. This is a more sophisticated approach, but it is also more in tune with the times. The traditional skills of the consultant, expert, solution provider are still required, but are applicable in certain situations only.

The new skills of the acceptant listener, client facilitated designer and structured group process provider will need to be added to one repertoire. The change master must develop the ability to diagnose given situation (what is being managed, who is managing and what we should be managing with—see Ku stedt, 1985) and to determine the necessary stages of evolution towards effective implementation. He or she must know when to push versus when to lie back and let people "incubate," or process, the changes taking place; learn how to create ownership solutions and decisions; become mature and wise enough to maria, the process and keep ego remove from content; believe that there are many paths to the same solution and that the one, the client feels most comfortable with will probably

Figure 2: Professional Mode-Client Change Matrix (Adapted from Morris, 1979)

	Professional Modes of Functioning	Stages of Change		
		Awareness	Willingness, Ability	Effective Implementation
Delegative	Delegator			
	Acceptant Listener			
	Facilitator			
	Structured group process provider (NGT)			
Participative	Participator			
	Collaborator, team member			
	Data gatherer			
Consultative	Consultator			
	Challenger			
	Teacher, skill spin-off, skill developer			
Autocratic	Expert, solution provider			
	Problem-solver			
	Decision maker			

the most effective; and learn how to administer quality control in an unobtrusive but effective fashion.

IE role in transition

Table 2 compares traditional IE areas of expertise and techniques and what one might call the IE areas of expertise and techniques that are necessary to support the organization of the future (organization Z). At first glance, the distinction between the two lists might appear to be purely semantic.

The areas of expertise on the right in many cases represent advanced stages of development of those areas listed on the left, or advanced sophistication relative to specific techniques and their application. In other cases, the lists differ in scope and focus. For instance, quality control versus total quality management incorporates the need to practice the lessons we taught the Japanese about how you achieve quality.

In some cases, the areas on the right represent a need for expanded knowledge and skill development on the part of the IE. This will very likely need to happen at the graduate level, in continuing education situations or through a self-teach mode. Performance and productivity measurement, strategic planning processes, organizational development, socio-technical systems design and management support systems design are all advanced topics requiring continuing professional development beyond the traditional IE undergraduate degree.

The IE professional must bring new and expanded knowledge and skills to the organization of the '80s and '90s if he or she is to play a prominent role in the evolution that is occurring in American business and industry. The needs for and demands placed on the IE function are changing.

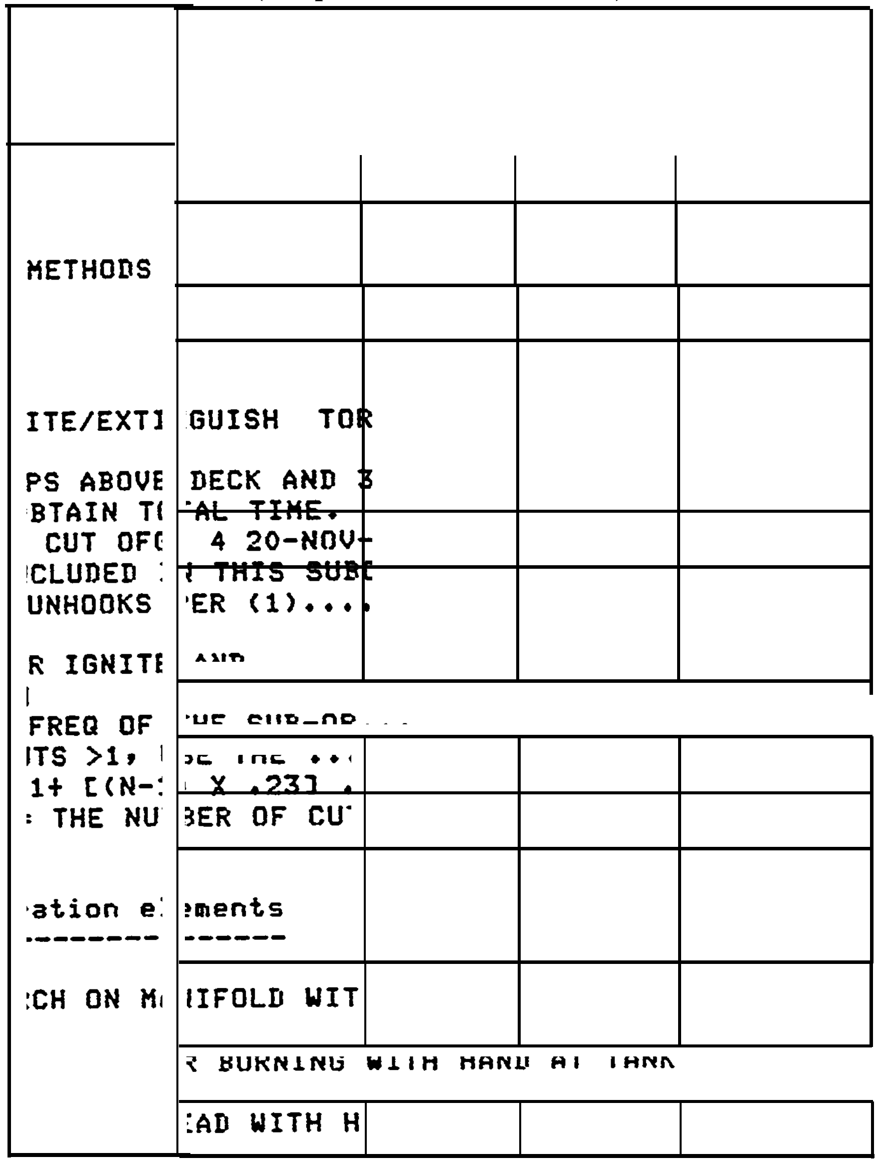
I believe that the IE has a unique educational background that would support a more prominent IE role in the exciting changes that will have to take place in the American organization. However, I also believe that IE curricula, particularly at the graduate level, must undergo a corresponding evolution (or revolution) in order for the IE profession to respond to these challenges.

I, for one, do not sense the felt urgency to reexamine old beliefs, old perceptions of what it takes to compete, old techniques and approaches as will be necessary to cause change in IE higher education. We are simply reacting to symptoms, failing to proactively analyze and plan for how we should educate the IE of the '80s and '90s.

A specific example of an attempt by an IE academic department to begin to address these needed curricula reforms is the newly designed management systems engineering graduate concentration at Virginia Tech. Management System Laboratory Director Kurstedt designed and developed the program to address many of the changes envisioned for American organizations over the next ten years.

The program builds on a solid engineering undergraduate degree by strengthening an IE undergraduate's basic engineering knowledge and by broadening the industrial engineering knowledge and skills of mechanical engineers, electrical engineers, chemical engineers, etc. All students in the concentration take nine hours

Figure 2: Professional Mode-Client Change Matrix
(Adapted from Morris, 1979)



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MANUAL METHODS

377. MAKE READY STAGING BRACKET FOR (TRANSPORTING) WITH HAND AT TANK (OR
WAY) CARPENTER
PER STAGING BRACKET OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS GETTING BRACKET READY TO BE..
* ...TRANSPORTED TO TANK OR BULKHEAD
* CARPENTER IS LOCATED EITHER ON THE WAY..
* ...OR IN TANK AT THE MATERIAL (BIN-1)
CARP-3 BEGINS AT BIN-1

1 CARP-3 GET+PLACE WITH BEND BRKT FROM BIN-1 TO BIN-1
2 CARP-3 GET+PLACE WITH BEND BOLT FROM TOOLBOX-1 TO BIN-1 AND INSE
BOLT IN BRKT
3 CARP-3 FASTEN NUT AT BIN-1 4 WRIST-TURNS USING HANDS
4 CARP-3 GET+PLACE BRKT FROM BIN-1 TO BIN-1 (PILE UP BRKTS FOR
TRANSPORTATION)

379. SET-UP STAGING BRACKETS ON BULKHEAD WITH WRENCH AT TANK CARPENTER
PER STAGING BRACKET OFG: 3 01-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS PUTTING UP A BRACKET ON AN...
* ...EXISTING STAGING CLIP
CARP-1 BEGINS AT TANKTOP

1 CARP-1 GET+HOLD WITH BEND BRKT FROM TANKTOP TO CARP-1
2 CARP-1 LOOSEN NUT AT BRKT-1 4 WRIST-TURNS USING HANDS
3 CARP-1 REMOVE BOLT FROM BRKT-1 (BRKT.) TO CARP-1
4 CARP-1 GET+PLACE BRKT FROM CARP-1 TO BRKT-1 AND INSERT BOLT
5 CARP-1 FASTEN NUT AT BRKT-1 13 WRIST-TURNS USING HANDS
6 CARP-1 FASTEN NUT AT BRKT-1 4 ARM-STROKES USING WRENCH-1 ASIDE
CARP-1
7 CARP-1 WALK TO BRKT-2 (TO DO NEXT BRKT)

Guidelines for Managing Organizational Change

Strategies and tactics that you can use when faced with the inevitable: your organization's continuing evolution.

Stan Wheeler
Manufacturing Consultant
EDS Corp.
Southfield, Mich.

Even though the shortest distance between two points is a straight line, the journey from an ineffective to an effective organization may follow a more meandering path, encumbered with unforeseen obstacles that often include an organization's own corporate culture. To successfully navigate such a perilous course requires a clear understanding of the pitfalls that can otherwise jeopardize the organizational change process.

What does it mean to say we have to "manage the organizational change process?" It entails directing efforts at improving the bottom-line performance of an enterprise. It implies support by training, transition to common systems, and organizational realignment and rationalization initiatives, where appropriate.

Until fairly recently, most enterprises initiated change as a reaction to a crisis. Today, the predilection to manage by reacting that once dominated American business is being preempted by a higher incidence of proactive change initiatives. However, the increasing recognition that to survive is to be proactive must be supported by a formal continuous improvement process for managing change.

The reward for successfully managing change is a sustained competitive advantage for improved market reach, better product quality, and improved cost structure.

Important prerequisites

Three prerequisites are essential to implementing change strategies for improved organizational effectiveness. First, top-level management must be committed and demonstrate direct involvement. Second, a formal continuous improvement process, as was already mentioned, must be in place. Finally, values that recognize the importance of the individual and the need for teamwork to solve problems must be adhered to.

Many companies use consulting services for help in facilitating the change process. Organizational change consultants brought from outside the company must understand the manufacturer's business to be able to offer objective insights into the dynamics of the operation that may not be readily apparent to those on the "inside."

Even if an internal "champion" of the change process knows what kinds of changes need to be made, he or she may not be aware of many of the techniques of effective change implementation. In other instances, companies look to consultants in hopes of overcoming internal resistance to change or even to shield the champion from the potentially adverse reactions of peers, subordinates or management. And if a project goes sour or recommendations for change are rejected, the consultant, rather than the champion, takes the heat.

To implement a change process a consultant examines and assesses the effectiveness of business practices and plans, accounting procedures, information systems, and organizational structure and culture. The focus can then be brought to bear on areas that include education, facilitation, motivation, project planning, and implementation of specific recommendations. Throughout the change process, the consultant will continually "test the waters" of the organizational culture to determine how much change it can endure at any given time. Matching implementation recommendations to the organization's cultural climate is essential to an effective change process.

Steps to effectiveness

Changing an organization to improve effectiveness involves several steps that allow definition and deployment of the following: a business plan that matches up well with the proposed organization; a methodology for evaluating and selecting new technology; a process for managing new product programs; an organizational structure properly aligned with supporting functions and those assigned to carry them out; and training systems needed to support the new organization's mission.

Figure 1 lists characteristics of ineffective and effective organizations. In fact, these are only a few of the many attributes that can be discussed in relation to every function within an organization. It is also important to note

FIGURE 1

INEFFECTIVE ORGANIZATION	EFFECTIVE ORGANIZATION
• Distant from customer	• Bonded with customer
• Cost-driven	• Profit-driven
• Traditional costing	• Activity-based costing
• Standalone R&D	• R&D linked with marketing
• Inappropriate measurements/rewards	• Effective measurements/rewards
• People viewed as costs	• People viewed as assets
• Firefighting	• Continuous improvement
• Quality taught	• Quality practiced
• Technology as a 'What'	• Technology as a 'How'
• Excessive rework and delays	• Minimal rework and delays
• Excessive lead time	• Lead time satisfies customer
• Information viewed as cost	• Information viewed as asset
• Proliferation of systems	• Common systems
• Standalone systems	• Integrated systems

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383. SET-UP (ACCESS) LADDER ON BULKHEAD WITH HAND AT TANK CARPENTER
PER LADDER OFG: 3 01-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS PUTTING UP AN ACCESS LADDER..
* ...ON THE BULKHEAD SO THAT THE CARPENTER
* ...CAN CLIMB TO THE NEXT LADDER.
* ALSO INCLUDES CLIMBING UP AND DOWN THE..
* ...LADDER.
* AVERAGE NUMBER OF RUNGS = 12
CARP-1 BEGINS AT TANKTOP

1 CARP-1 GET+PLACE WITH BEND LADR FROM TANKTOP TO LDR
2 CARP-1 SLIDE (CLIMB-UP) LADDER AT LDR (12 RUNGS) PF 12 (1)
12 (3 4)
3 CARP-1 PULL (CLIMB-DOWN) LADDER AT LDR (12 RUNGS) PF 12 (1
12 (3 4)

385. POSITION (SECURE) (ACCESS) LADDER FOR BRACKET STAGING WITH PLIER (A
WIRE ROPE) AT TANK CARPENTER
PER LADDER OFG: 4 03-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS SECURING LADDER TO STAGING...
* ...BOARDS USING WIRE ROPE
CARP-1 BEGINS AT LDR

1 CARP-1 GET+MANIPULATE WIRE-ROPE AT LDR (PUT AROUND BOARDS AND
LADDER.)
2 CARP-1 TWIST WIRE-ROPE AT LDR USING PLIER-1 ASIDE TO CARP-1

386. MAKE READY STAGING PLANK FOR (TRANSPORTING) WITH HAND AT TANK (OR
CARPENTER
PER STAGING PLANK OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS GETTING BOARD ON BOLSTERS SO
* ...THAT THE CRANE CAN TRANSPORT IT
CARP-3 BEGINS AT BIN-1

1 CARP-3 GET+SLIDE BOARD AT LU-PILE AND ADJUST (ON BOLSTERS)

MANUAL METHODS

388. SET-UP STAGING PLANK ON STAGING BRACKET WITH HAND AT TANK CARPENTER
PER BOARD OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS SETTING UP BOARDS BETWEEN....
* ...BRACKETS.
* TWO MAN OPERATION:
* CARPENTERS ARE LOCATED AT TWO DIFFERENT
* ..BRACKETS. THEY BOTH LIFT THE BOARD....
* ..TOGETHER AND SLIDE IT INTO POSITION.
* IN THIS ANALYSIS CARPENTERS ARE LOCATED
* ...ON THE LEVEL BELOW THE BOARDS.
CARP-1 BEGINS AT BRKT-1

1 CARP-1+CARP-2 GET+SLIDE WITH 1 STEP BOARD AT BRKT-1 AND ALIGN
2 CARP-1 WALK TO BRKT-2 (TO DO NEXT SECTION OF BOARDS, CARP2 ALSO MOVES TO ANOTHER BRACKET)

389. SET-UP STAGING PLANK ON STAGING BRACKET WITH HAND AT TANK CARPENTER
PER BOARD OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS SETTING UP BOARDS BETWEEN....
* ...BRACKETS.
* TWO MAN OPERATION:
* CARPENTERS ARE LOCATED AT TWO DIFFERENT
* ..BRACKETS. THEY BOTH PICK-UP THE BOARD
* ..TOGETHER AND SLIDE IT INTO POSITION.
* IN THIS ANALYSIS CARPENTERS ARE LOCATED
* ...ON THE SAME LEVEL AS THE BOARDS.
CARP-1 BEGINS AT BRKT-1

1 CARP-1+CARP-2 GET+SLIDE WITH BEND WITH 1 STEP BOARD AT BRKT-1 AND ALIGN
2 CARP-1 WALK TO BRKT-2 (TO DO NEXT SECTION OF BOARDS, CARP2 ALSO MOVES TO ANOTHER BRACKET)

MANUAL METHODS

390. SET-UP STAGING PLANK ON STAGING BRACKET WITH HAND AT TANK CARPENTER
PER STAGING PLANK OFG: 4 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS SETTING UP BOARDS BETWEEN....
* ...BRACKETS.
* ONE MAN OPERATION:
* USUALLY OCCURS WHEN CRANE CANNOT PLACE..
* ...BOARD ON BRACKETS.
CARP-1 BEGINS AT BRKT-1

1 CARP-1 GET+MANIPULATE WITH BEND BOARD AT BRKT-2 AND ALIGN RETURN
BRKT-1
2 CARP-1 GET+POSITION WITH BEND BOARD FROM TANKTOP TO BRKT-1 AND S

391. MAKE READY STANCHION FOR (TRANSPORTING) WITH HAND AT TANK (OR WAY)
CARPENTER
PER STANCHION OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS GETTING STANCHION READY TO BE
* ...TRANSPORTED.
CARP-3 BEGINS AT LU-PILE

1 CARP-3 GET+PLACE WITH BEND STAN FROM BIN-2 TO BIN-2

393. SET-UP STANCHION IN STAGING BRACKET WITH HAND AT TANK CARPENTER
PER STANCHION OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS PUTTING STANCHION IN THE.....
* ...BRACKET SLEEVE.
CARP-1 BEGINS AT BRKT-1

1 CARP-1 GET+PLACE WITH BEND STAN FROM TANKTOP TO BRKT-1 AND INSEF
2 CARP-1 WALK TO BRKT-2 (DO NEXT STANCHION)

MANUAL METHODS

394. MAKE READY HANDRAIL FOR (TRANSPORTING) WITH HAND AT TANK (OR WAY)
CARPENTER
PER HANDRAIL OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS GETTING HANDRAIL ON BOLSTERS
* ...SO THAT THE CRANE CAN TRANSPORT IT
CARP-3 BEGINS AT BIN-2

1 CARP-3 GET+SLIDE HANDRAIL AT HR-PILE AND ADJUST (ON BOLSTERS)

396. SET-UP HANDRAIL ON STANCHION WITH HAND AT TANK CARPENTER
PER HANDRAIL OFG: 3 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS PUTTING HANDRAIL INTO THE....
* ...EYELETS ON THE STANCHION
* INCLUDES ACTION DISTANCES NEEDED FOR....
* ...ALIGNING THE HANDRAIL
* WELDING OF THE HANDRAIL CONNECTIONS WILL
* ...BE DONE IN A SEPARATE SUB OPERATION
CARP-1 BEGINS AT BRKT-1

1 CARP-1 GET+SLIDE WITH BEND HANDRAIL AT BRKT-2 AND ALIGN (THRU 2 EYELETS ON THE STANCHIONS AT. BRKT1 & BRKT2) RETURN TO BRKT-1 PF 2 (4 5 6)
2 CARP-1 WALK TO BRKT-2 (DO NEXT SECTION)

MANUAL METHODS

397. SET-UP HANDRAIL (END PIECES) ON HANDRAIL (AND BULKHEAD) WITH HAND A
TANK CARPENTER
PER HANDRAIL OFG: 4 02-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS PUTTING HANDRAIL (END PIECES)
* ...AT THE END OF A STAGING LEVEL
* WELDING OF THE HANDRAIL (END PIECES)....
* ...CONNECTIONS WILL BE DONE IN A........
* ...SEPARATE SUB OPERATION
CARP-1 BEGINS AT BRKT-1

1 CARP-1 GET+HOLD WITH BEND HANDRAIL FROM TANKTOP TO CARP-1
2 PTIME 1.02 M (CUT HANDRAIL INTO 2 PIECES WITH ELECTRODE)
3 CARP-1 GET+PLACE 2 HANDRAIL (END PIECES) FROM CARP-1 TO BRKT-1

398. TEAR DOWN HANDRAIL ON BULKHEAD WITH TORCH AT (CENTER) MID TANKS AN
VOIDS CARPENTER
PER HANDRAIL OFG: 3 04-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS TEARING DOWN HANDRAIL IN A...
* ...CENTER TANK. HANDRAIL IS THROWN TO A
* ...MATERIAL PILE ON THE TANKTOP.
* CARPENTERS REMOVE 2 HADNRAIL BEFORE.....
* ...MOVING TO NEXT SECTION.
CARP-1 BEGINS AT BULKHEAD

1 CARP-1 PULL TORCH FROM BULKHEAD TO BRKT-1
2 CARP-1 OPERATE TORCH AT BRKT-1 PTIME 0.26 M (BURN OFF HANDRAIL
3 CARP-2 GET+HOLD HANDRAIL FROM BRKT-1 TO CARP-2 SIMO
4 CARP-2 HOLD+THROW HANDRAIL FROM CARP-2 TO MATL-PILE
5 CARP-1 AND CARP2 WALK TO BRKT-2 F 1 / 2

UNDERSTANDING VARIATION

- SHIPBUILDERS ARE AWARE OF STATISTICAL PROCESS CONTROL(SPC) THROUGH ITS USE IN ACCURACY CONTROL
- HOWEVER, THEY DO NOT APPEAR TO BE AWARE OF ITS REAL USES
- SPC WAS ORIGINALLY DEVELOPED AS A MANAGEMENT DECISION TOOL NOT JUST A PRODUCT QUALITY CONTROL
- EVERY PROCESS HAS NATURAL LIMITS AND THEY CANNOT BE CHANGED UNLESS THE PROCESS IS CHANGED
- SPC APPLIED TO BUDGET/MAN HOUR VARIANCE REPORTS MAY SHOW THAT THE CHANGES IN THE VARIANCES ARE WITHIN THE NATURAL PROCESS LIMITS OF THE PROCESS USED

UNDERSTANDING VARIATION (Continued)

- MANY REACTIONS TO APPARENT SIGNALS IN TRADITIONAL VARIANCE ARE WRONG. APPLICATION OF SPC TO THE SAME DATA WOULD SHOW THIS

- MANAGING A COMPANY BY MEANS OF MONTHLY REPORTS IS LIKE DRIVING A CAR BY WATCHING THE ROAD IN THE REAR VIEW MIRROR (Myron Tribus)

- NEVER THE LESS THIS IS WHAT MOST MANAGERS DO

UNDERSTANDING VARIATION (Continued)

- **DR. WALTER SHEWART, WHO DEVELOPED SPC, HAS TWO RULES FOR PRESENTATION OF DATA, NAMELY;**

  [1] DATA SHOULD AL WAYS BE PRESENTED IN SUCH A WAY THAT PRESERVES THE EVIDENCE IN THE DATA FOR ALL PREDICTIONS THAT MIGHT BE MADE FROM THESE DATA

  [2] WHENEVER ANA AVERAGE, RANGE, OR HISTOGRAM IS USED TO SUMMARIZE DATA, THE SUMMARY SHOULD NOT MISLEAD THE USER INTO TAKING ANY ACTION THAT THE USER WOULD NOT TAKE IF THE DATA WERE PRESENTED IN A TIME SERIES

- **THESE TWO *RULES* WERE SUMMARIZED BY D. WHEELER AS FOLLOWS:**

  NO DATA HAVE MEANING APART FROM THEIR CONTEXT

UNDERSTANDING VARIATION (Continued)

D. WHEELER FURTHER NOTES THAT:

NO COMPARISON BETWEEN TWO VALUES CAN BE GLOBAL

MANAGEMENT REPORTS ARE FULL OF LIMITED COMPARISONS

GRAPHS MAKE DATA MORE ACCESIBLE TO THE HUMAN MIND THAT DO TABLES

NUMERICAL SUMMARIES OF DATA MAY SUPPLEMENT GRAPHS, BUT THEY CAN NEVER REPLACE THEM

UNDERSTANDING VARIATION (Continued)

PLANS, GOALS, BUDGETS AND TARGETS ARE ALL SPECIFICATIONS

COMPARING MANAGEMENT DATA TO PLANS, GOALS, ETC., IS A FOLLOW ON DIRECTLY FROM THE MANUFACTURING PRACTICE OF COMPARING PRODUCT MEASUREMENTS WITH SPECIFICATION LIMITS

THIS LEADS TO A BINARY VIEW DUE TO THE FACT THAT THE OUTCOME OF COMPARISON WILL BE EITHER FAVORABLE OR UNFAVORABLE

WORKERS WITH FAVORABLE MEASURES GET PRAISE WHILE THE OTHERS ARE PENALIZED

SECTION 3
MANUAL METHODS

435. WELD STAGING BRACKET (CLIP) ON BULKHEAD (OR ANY STRUCTURE) WITH ST
ELECTRODE AT ANY TANKS AND VOIDS (SHIP) WELDING
PER 100 CLIPS OFG: 3
WELD TO MEET SAFETY REQUIREMENTS. RATE PER 100 CLIPS. RATE INC
MANUAL ELEMENTS.

1 WELD VERTICAL 3/8" FILLET WELD (10" PER CLIP) WITH 10% OVERWELI
USING 6011 3/16 ELECTRODE OR COMPARABLE (7018 5/32).

438. WELD LADDER (CLIP) (SECURES LADDER) ON BULKHEAD (OR ANY STRUCTURE)
STICK ELECTRODE AT ANY TANKS AND VOIDS (SHIP) WELDING
PER 100 LADDERS OR 400 CLIPS OFG: 3
WELD TO MEET SAFETY REQUIREMENTS. RATE PER 100 LADDERS (400 CL
RATE INCLUDES MANUAL ELEMENTS.

1 WELD VERTICAL 3/8" FILLET WELD (4" PER CLIP) WITH 10% OVERWELD
6011 3/16 ELECTRODE OR COMPARABLE (7018 5/32).

440. WELD HANDRAIL (CONNECTIONS) ON STANCHION WITH STICK ELECTRODE AT
TANKS AND VOIDS (SHIP) WELDING
PER 100 PIECES OF HANDRAIL OFG: 3
WELD TO MEET SAFETY REQUIREMENTS. RATE PER 100 PIECES OF AHNDR
(AVG. 1 CONNECTION EACH). RATE INCLUDES MANUAL ELEMENTS.

1 WELD HORIZONTAL 1/4" FILLET WELD (5" PER CONNECTION) USING 601
ELECTRODE OR COMPARABLE (7018 5/32).

```
                         IDS

'ER LADDER OFG: 3 05-FEB-82
  REPRESENTS ELAPSED TIME
 * REPRESENTS CARPENTERS CLIMBING UP AND...
 * ...DOWN LADDERS TO REMOVE STAGING.
 * AVERAGE LADDER SIZE = 12 RUNGS.
:ARP-1  BEGINS AT LDR
```

Many years ago, David Chambers found the following time series on the wall of the office of the president of a shoe company. Here was a simple and powerful presentation of data in context. The caption on the. vertical axis was “Daily Percentage of Defective Pairs.”

```
 * ... PILE ON TANKTOP TO DECK (GOING THRU
 * ...MANHOLE).
 * MAXIMUM NUMBER OF HANDRAIL IN LIFT = 6
CARP-3 BEGINS AT TANKTOP

 1 CARP-3 GET+SLIDE HANDRAIL ( ONTO BOLSTER ) AT MATL-PILE
 2 WINCH-OPER PUSH WINCH-DOWN PROCESS ( TO TANKTOP ) F 1 / 6
 3 WINCH-OPER LOOSEN ( =SWING ) CABLE WITH BEND AT MENHOLE 5
    ARM-STROKES USING HANDS F 1 / 6
 4 WINCH-OPER THROW CABLE FROM MENHOLE TO CARP-3 F 1 / 6
 5 CARP-3 GET+MANIPULATE WITH BEND CABLE AT MATL-PILE ( HOOK AROUND
    HANDRAIL ) F 1 / 6
 6 WINCH-OPER PUSH WINCH-FREE PROCESS ( CLEAR OBSTACLES ) F 1 / 6
 7 WINCH-OPER PUSH WINCH-UP PROCESS ( TO MENHOLE ) F 1 / 6
```

Intrigued, David asked the president why he had the graph on the wall. The president condescendingly replied that he had the chart on the wall so he could tell how the plant was doing.

David immediately responded with “Tell me how you’re doing.”

Evidently no one had had the temerity to ask the president this, because he paused, looked at the chart on the wall, and then said “Well, some days are better than others!”

other function of the raw data While there are several different types o control charts, they are all interpreted in the same way, and they all revea different aspects of the voice of the process.

Not only does the control chart define the voice of the process, it alsc characterizes the behavior of the time series. Occasionally one wil encounter a time series which is well-behaved: such time series **are pre** dictable, consistent, and stable over time. More commonly, time series are not well-behaved: they are unpredictable, inconsistent, and changin over time. The lines on a control chart provide reference points for use ir deciding which we of behavior is displayed by any given time series..

If a time series displays unpredictable behavior, then the underlying process which gives rise to the time series is said to be "out-of-control." On the other hand, a process "will be said to be in control when, througl the use of past experience, we can predict, at least within limits, how the

4 WINCH-OPER THROW CABLE FROM Thus, the essence of statistical contro is predictability, and the opposite is also true. A process which does not display a reasonable degree of statistical control is unpredictable.

This distinction between predictability and unpredictability is impor-tant because prediction is the essence of doing business. Predictability is a great asset for any process because it makes the manager's job that mucl easier. When the process is unpredictable, the time series will be unpre-dictable, and this unpredictability will repeatedly undermine all of-our best efforts. In fact, attempting to make plans using a time series which is unpredictable results in more frustration than success. Prediction re-

1 CARP-3 GET+PLACE WITH BEND BRKT F

The control chart in Figure 2.6 shows a time series which consists o 67 consecutive points. The fact that the time series remains within the computed limits, and the fact that there is no obvious trend, nor any long sequences of points above or below the central line, suggests that this pro-cess may display a reasonable degree of statistical control. If the time

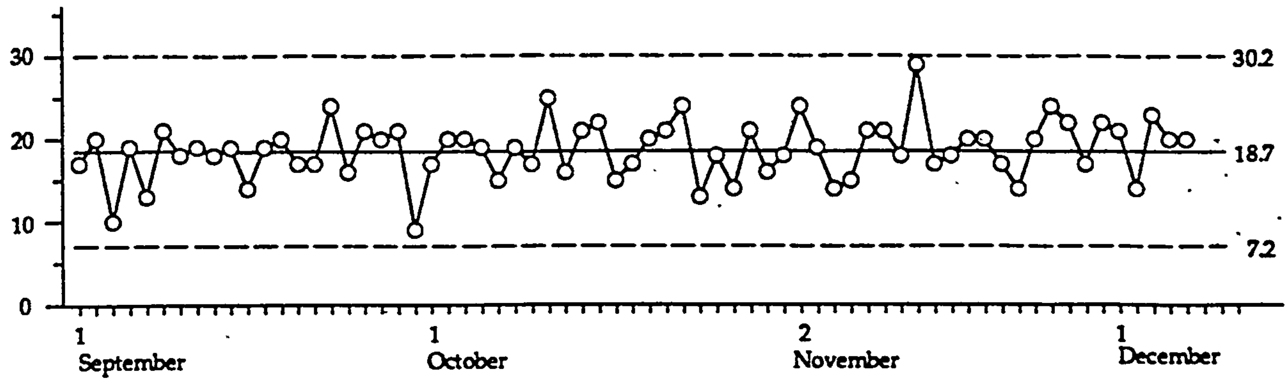

Figure 2.6: Control Chart for Daily Percentage of Defective Pairs

series continues to display this behavior, then we will naturally become more confident about using the past to predict the future. In this case, while the process has averaged 18.7% defectives, the daily values have varied from a low of 8% to a high of 29%. Based on this control chart, it would appear that *unless the process is changed in some fundamental way* the plant will continue to produce anywhere from 7% defectives to 30% defectives, with a daily average of about 19% defective.

Notice how the control chart has helped to interpret the data. First the chart is used to characterize the behavior of the data—are they predictable or not? Second, the control chart allows the manager to predict what to expect in the future—the voice of the process!

Finally, notice the difference between the president's interpretation of these data and the interpretation based on the control chart. Some days *only appeared* to be better than others! 37 days were "worse than average" (*i.e.* above 18.7%), and 30 days were "better than average," but *the process shows no evidence of any changes during the past 67 days!* In truth, both the "good" days and the "bad" days came from the same process. Unless, and until, this underlying process is changed in some fundamental manner, the president will continue to plot values which average about 19% defective. Looking for differences between the "good" days and the "bad" days will simply be a waste of time.

MATERIAL COSTS

This example tells the story of a traditional improvement effo considers several different measures of activity together. As before Monthly Report format for presenting results had obscured the big ture. The use of control charts allows one to collect the multiple st together and gain the needed perspective.

At one time Department 13 had material costs which amounted t percent of their production costs. During what we shall call Year O project team was formed and given the job of reducing the material in Department 13.

During August of Year One, a process change was made which designed to reduce the material utilization. Following this change average material cost per 100 pounds of material dropped from $21 to $208.20.

During March of Year Two, another process modification implemented. During the next four months the material cost droppe an average of $205.37 per 100 pounds produced.

In July of Year Two a change was made in the formulation o material used in Department 13. This change resulted in an av material cost of $201.22 per 100 pounds produced. One month late project team and Department 13 got an award for these successful reductions.

Finally, in January of Year Three, Department 13 changed sup for some of their raw materials. This resulted in an average material of $198.45 per 100 pounds produced.

Against this background the monthly report for July of Year showed the following values for Department 13:

MANUAL METHODS

563. TRANSPORT STAGING BRACKET WITH (TOWER CRANE) AT (WING) TANKS AND VOIDS
CARPENTER
PER STAGING BRACKET OFG: 3 23-MAY-83
REPRESENTS ELAPSED TIME
* REPRESENTS TRANSPORTING BRACKETS FROM...
* ...BIN-1 TO BULKHEAD
* DISTANCES FROM CRANE-REST TO BIN-1 AND..
* ...FROM BIN-1 TO BULKHEAD ARE AVERAGE...
* ...DISTANCES FROM THE SIDE OF A BASIN
* ...1200'X200'
* MAXIMUM NUMBER OF BRKTS IN LIFT = 6
C-OPER BEGINS AT CR-1

1 TRANSPORT BRKT FROM BIN-1 USING CRANE WITH HOOK+SLING TO BULKHEAD (BTWN BRKTS) PLACE+ADJUST RETURN TO CR-1 F 1 / 6

564. TRANSPORT LADDER WITH (TOWER CRANE) AT (WING) TANKS AND VOIDS CARPENTER
PER LADDER OFG: 3 23-MAY-83
REPRESENTS ELAPSED TIME
* REPRESENTS TRANSPORTING LADDERS FROM
* ...LDR-PILE TO BULKHEAD
* DISTANCES FROM CRANE-REST TO LDR-PILE
* ...AND FROM LDR-PILE TO BULKHEAD ARE
* ...AVERAGE DISTANCE FROM SIDE OF BASIN
* ...1200'X200'
* MAXIMUM NUMBER OF LADDERS IN LIFT = 3
C-OPER BEGINS AT CR-1

1 TRANSPORT LADR FROM LDR-PILE USING CRANE WITH HOOK+SLING TO BULKHEAI (AT. LDR) PLACE+ADJUST RETURN TO CR-1 F 1 / 3

Material Costs Per 100 Pounds												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	214.79	215.22	214.79	214.36	216.51	213.71	216.79	216.08	208.34	208.76	206.67	208.34
Two	210.43	206.67	206.13	206.13	205.11	204.09	202.09	201.89	201.69	201.49	201.09	199.09
Three	198.69	197.89	198.09	199.68	198.88	197.70	198.29					

Figure 5.6: Material Costs for Department 13

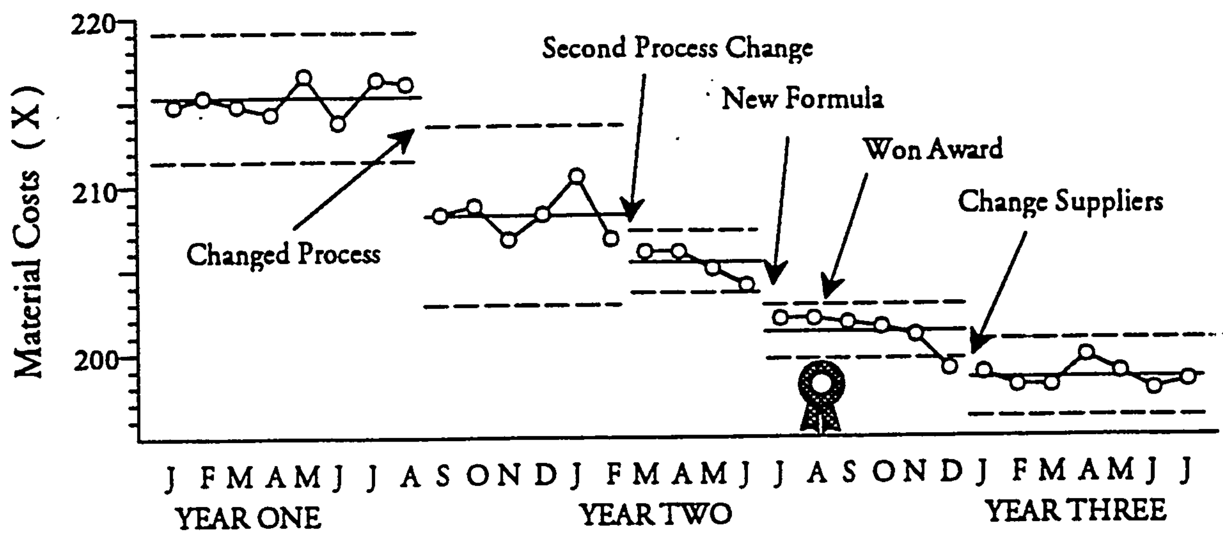

Figure 5.7: X-Charts for Material Costs

The material costs are shown in Figure 5.7. The gaps in the record correspond to the changes made by the project team. The effectiveness of these changes can clearly and easily be seen on this graph.

The limits shown with each segment are the Natural Process Limits for individual values. The moving ranges used to obtain these limits are not shown in the interest of keeping the graph from becoming too busy. By comparing the *limits* for one segment with the *running record* of another segment one can see that the changes made by the project team did result in definite and real reductions in the material costs.

Manhours Per 100 Pounds												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	3.87	3.86	3.90	3.93	3.92	3.86	3.92	3.90	4.02	3.95	4.01	3.95
Two	4.01	4.00	4.06	4.10	4.07	4.09	4.26	4.24	4.27	4.24	4.26	4.29
Three	4.43	4.45	4.47	4.47	4.51	4.43	4.45					

Figure 5.8: Manhours for Department 13

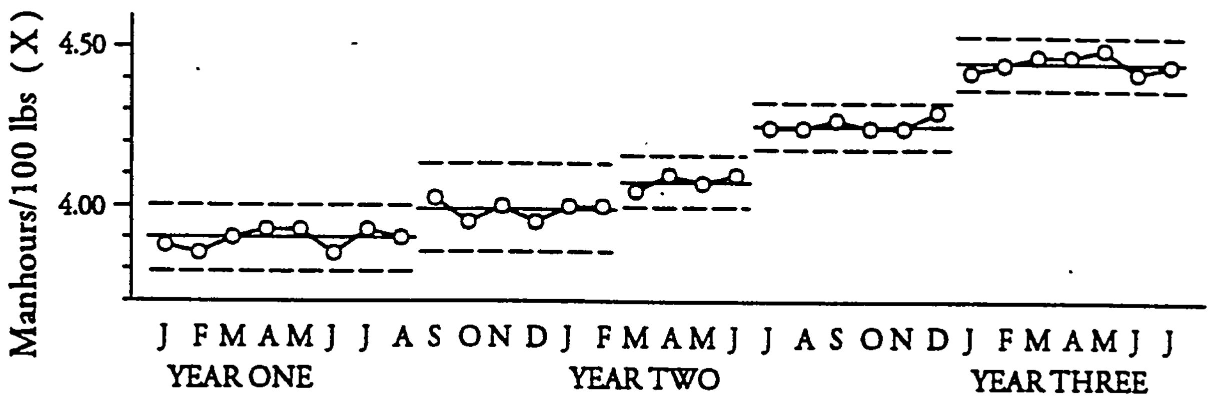

Figure 5.9: X-Charts for Manhours Per 100 Pounds

The manhours per 100 pounds of product are shown in Figure 5.9. The gaps in the record correspond to the changes made by the project team. The limits for each segment were computed using the moving ranges for that segment, even though the moving range charts are not shown in this figure.

The graph in Figure 5.9 shows that there have been increases in the number of manhours per 100 pounds of product. *Each and every change made by the project team had the effect of increasing the actual labor content of the product.*

The small amount of month-to-month variation in this time series makes it easy to interpret this graph. Placing Natural Process Limits on each segment just makes it clearer that these incremental increases are real.

The production volumes are shown in Figure 5.11. The gaps in the record correspond to the changes made by the project team. The limits shown were computed from the first eight values and their moving

Production Volumes (thousands of pounds)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	39.1	38.7	38.8	39.7	42.3	43.3	42.0	44.4	42.3	41.3	36.9	38.3
Two	40.1	40.4	36.5	41.8	40.5	39.1	35.2	37.5	34.7	39.7	37.9	36.4
Three	39.1	36.0	35.5	34.6	36.8	35.0	34.5					

Figure 5.10: Production Volumes for Department 13

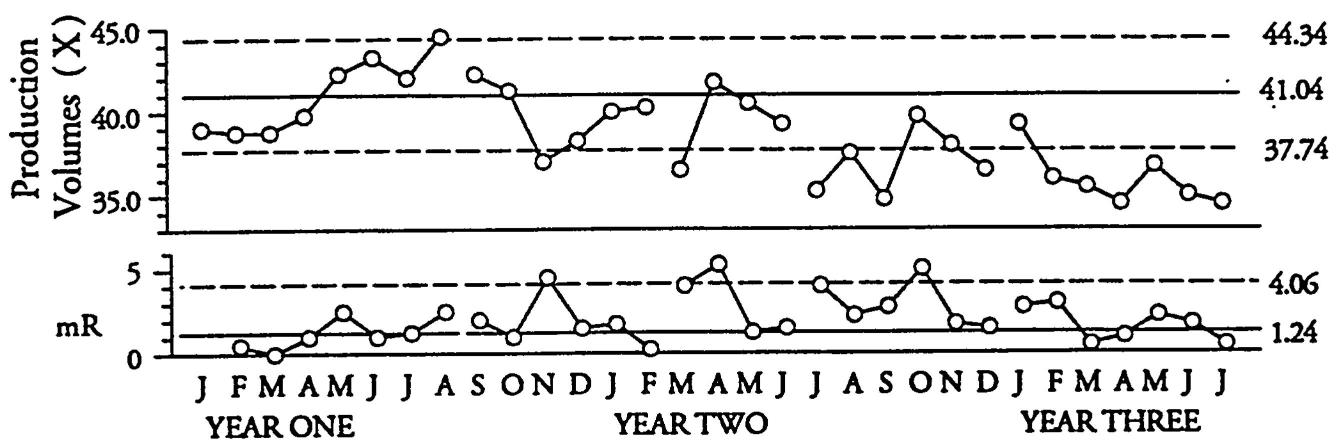

Figure 5.11: ***XmR*** **Chart for Production Volumes**

ranges. The first eight values suggest an upward trend for the production volumes. However, following the first process change, and continuing through the subsequent changes, there is a downward trend in the production volume. In addition to the two large transition ranges, the moving range chart shows three other out-of-control ranges. These three values suggest three additional changes in the level of production in Department 13. If these were deliberate changes made by management, then there is no need to look for assignable causes. If these changes were surprises, then there is something to be gained by looking for the assignable causes behind these shifts.

Thus, the production volumes are down while the manhours per 100 pounds are up—*a classic description of declining productivity—totally buried in the figures in the Monthly Report.*

Energy and Fixed Costs (per 100 pounds)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	8.96	9.08	8.97	9.25	9.50	9.12	9.21	9.32	9.44	9.60	9.82	9.75
Two	9.74	9.96	10.02	10.05	10.34	10.32	10.19	10.19	10.33	10.57	10.87	10.33
Three	10.82	10.61	10.92	11.12	11.18	11.16	11.34					

Figure 5.12: Energy and Fixed Costs for Department 13

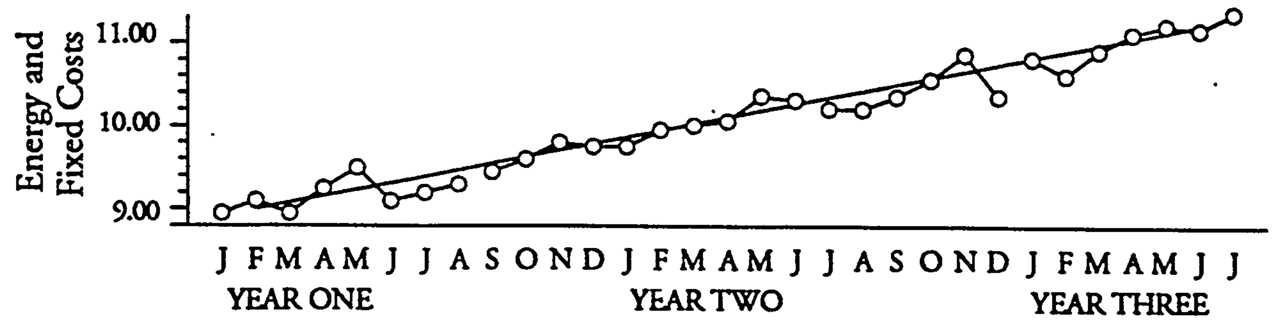

Figure 5.13: Running Record for Energy and Fixed Costs

The energy and fixed costs are shown in Figure 5.13. The gaps in the record correspond to the changes made by the project team.

The energy and fixed costs have risen as expected. In fact, the running record shows a fairly straight line sloping upward. Note the difference between this graph and the graph for manhours per 100 pounds. The slope of the points extends across the gaps. There is no suggestion of a step increase at the gaps like there was with the manhours data.

The sloping line shown was drawn by connecting the average of the first three values with the average of the last three values. The average of the first three values was plotted above February of Year One, while the average of the last three values was plotted above June of Year Three.

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Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Total Production Costs (per 100 pounds)						
One	281.80	282.80	282.26	282.56	284.81	280.73	284.30	283.90	278.08	277.61	276.64	277.34
Two	282.33	282.39	279.08	279.73	278.54	277.81	278.31	277.80	278.21	277.78	277.99	275.92
Three	280.39	279.70	280.53	282.32	282.22	279.74	280.83					

Figure 5.14: Total Production Costs for Department 13

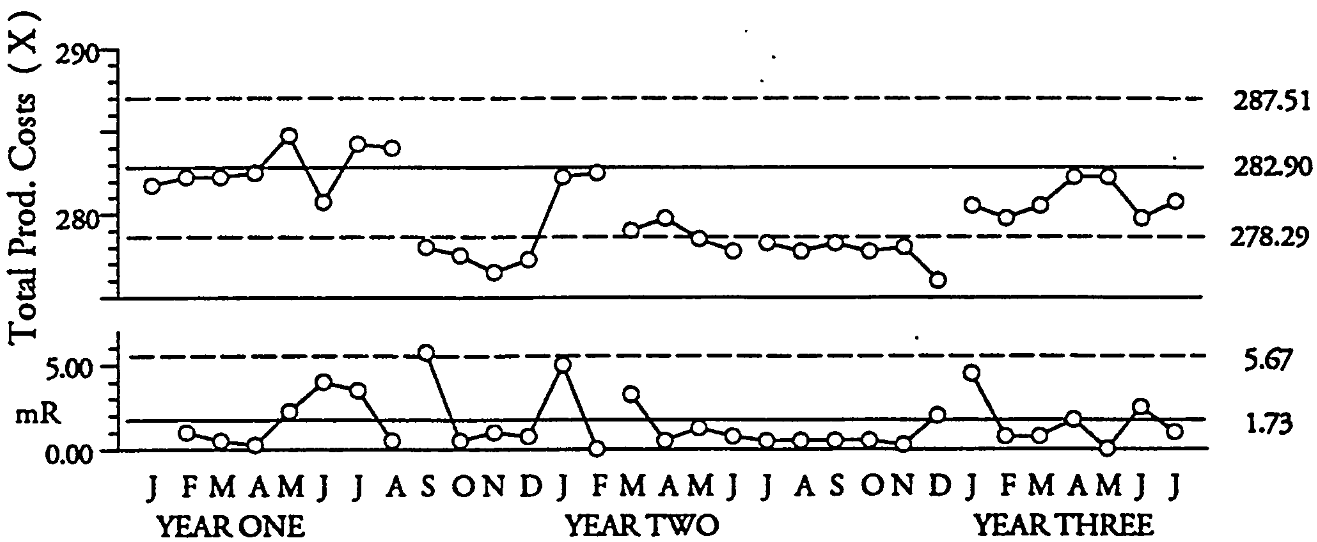

Figure 5.15: *XmR* Chart for Total Production Costs per 100 Pounds

The total production costs are shown in Figure 5.15. The gaps in the record correspond to the changes made by the project team. The limits shown are based upon the first eight values and their moving ranges.

The first process change resulted in a definite drop in the total production cost, although inflation of other costs had eroded these gains by the first two months of Year Two. The second process change caused another drop in the total production cost. Finally, even though the final change at the beginning of Year Three did reduce the material cost, the increases in the other costs have offset this gain. Still, all in all, they are doing better than they were at the beginning of Year One, or at least it would appear that way from these data.

While the total cost data and the material cost data look good, and the energy costs look pretty much like they should look, there are some indications of trouble in the time series for manhours and production volumes. All of these measures are computed for Department 13. Unfortunately, Department 13 does not use its own stuff, and therefore it has no way of assessing the quality of its product.

The figures developed from the records in Department 13 cannot take the quality of the product into account. This makes all of the cost figures suspect, because they are based on pounds shipped, not pounds converted into usable product in Department 14.

Department 14, on the other hand, keeps careful track of their successful conversion rate. Among the problems that can occur in Department 14, the major cause of scrap is "will not mold." The category has been shown to be most directly affected by the quality of the component supplied by Department 13.

The percentages of scrap (by weight) due to "will not mold" are shown in Figure 5.16, and the values are plotted in Figure 5.17.

Percentage of Material Lost Due to "Will Not Mold"

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	2.7	2.0	1.6	1.8	2.1	2.7	1.6	2.4	4.5	4.0	2.9	3.4
Two	4.5	4.3	7.7	7.2	8.4	6.3	11.3	10.8	10.5	12.8	9.8	11.9
Three	16.3	17.6	14.6	15.5	17.9	15.8	14.8					

Figure 5.16: Scrap Percentages for Department 14

193

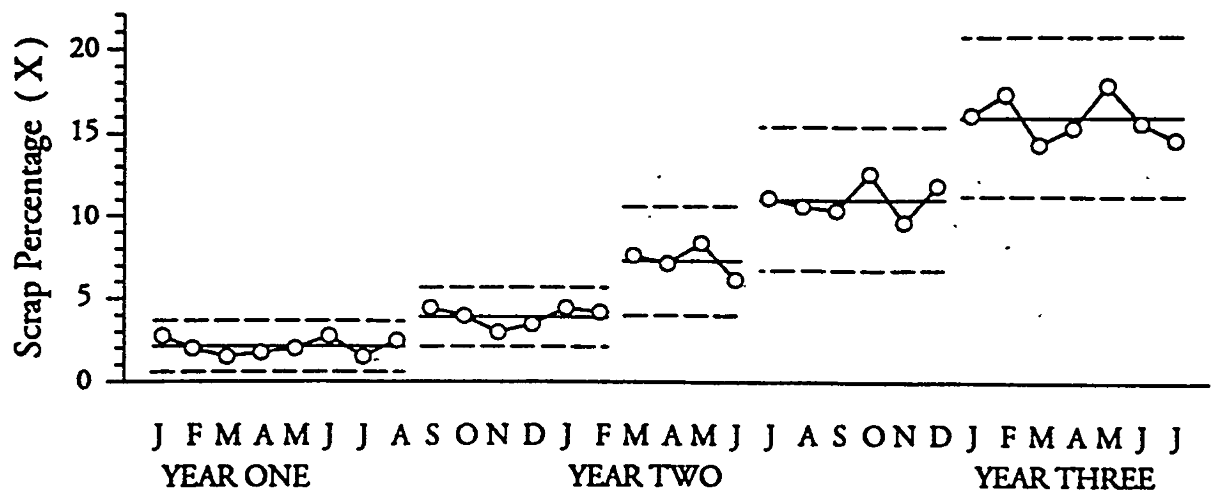

Figure 5.17: X-Charts for Scrap Percentages for Department 14

The Natural Process Limits are shown for each segment in Figure 5.17. While each segment stays within its own set of limits, each segment, beginning with September of Year One, is out-of-control relative to the preceding set of limits. This means that each and every signal in these data correspond to one of the changes made by the project team in Department 13.

This negative impact of the project team's efforts was not seen because of the artificial boundary created by the "departments" and the subsequent partitioning of the management data. While everyone was minding their own department, no one was minding the store.

If we delete the pounds of scrap produced in Department 14 from the total amount of product produced in Department 13, then the data for Department 13 will tell a different story. We begin by taking the total production costs and scaling them to reflect the scrap rate due to "will not mold."

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	289.62	287.96	286.85	287.74	290.92	288.52	288.92	290.88	291.18	289.18	284.90	287.10
Two	295.63	295.08	302.36	301.43	304.08	296.49	313.77	311.44	310.85	318.56	308.19	313.19
Three	334.99	339.44	328.49	334.11	343.75	332.2	329.61					

Honest (Actual) Production Costs
(per 100 pounds of usable product)

Figure 5.18: Honest Production Costs for Department 13

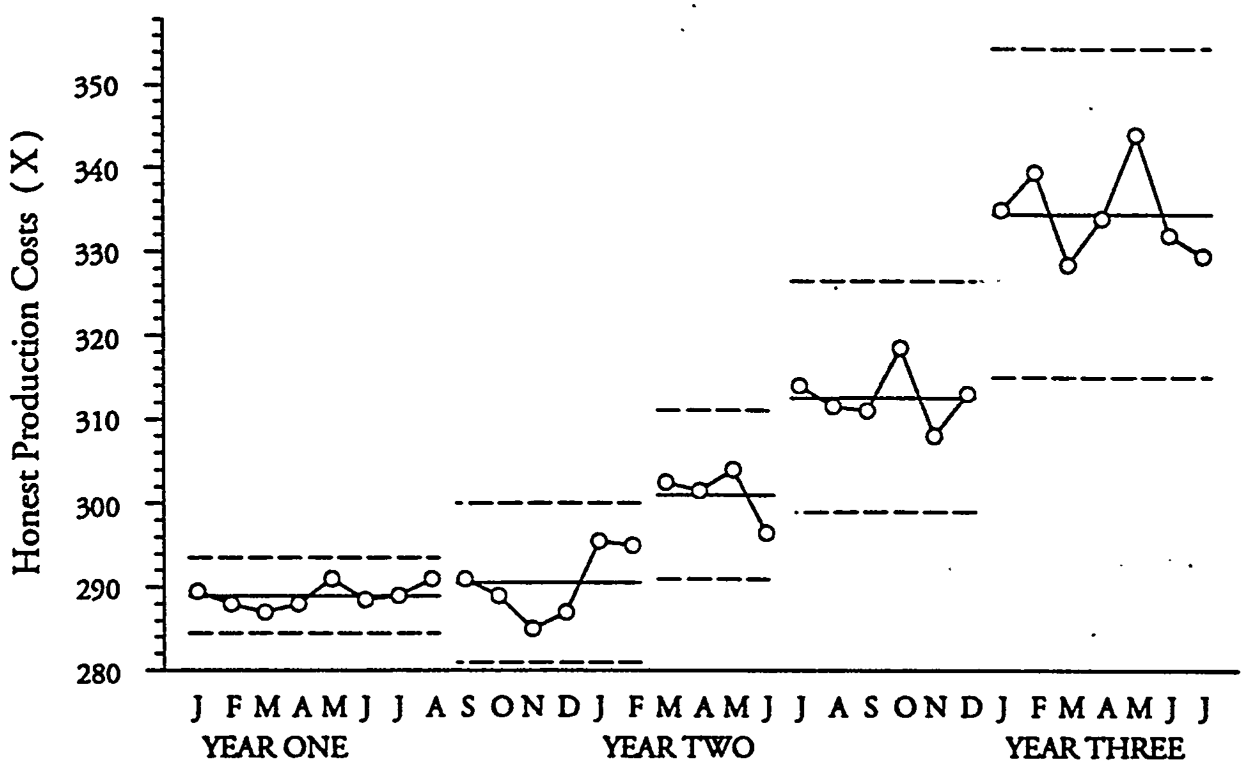

Figure 5.19: X-Charts for Honest Production Costs for Department 13

Figure 5.19 shows the net value to the company of the changes made by the project team in Department 13. They effectively increased the total cost of the finished product, and they got an award for doing it! One cannot help but recall Dr. Deming's first theorem : *"No one gives a hoot about profits—if they did they would be interested in learning better ways to make them."*

What if the changes had not been made? What if Department 13 had done nothing? The total cost per 100 pounds of usable product may be estimated as follows.

Assume that Dept. 13 continued to use the same process, with the same supplier, and without the modifications in material usage or formulation. Assume material costs go up 5 percent each year. Allow for the increases in wages and the increases in energy costs which are known to have occurred. Assume that the scrap rate in Dept. 14 averages the 2.1 percent shown by the first eight months of Year One, and assume that the labor content of the product stays the same as it was at the beginning of Year One. These conditions will result in the estimated total production costs shown in Figures 5.20 and 5.21.

The company would have come out ahead if they had kept the production system which was in place at the beginning of Year One and sent the project team for a two-year, expense-paid vacation in Cuba.

The second tragedy of this story is that the managers had too much invested in the "improvement" effort to admit that it had been a failure.

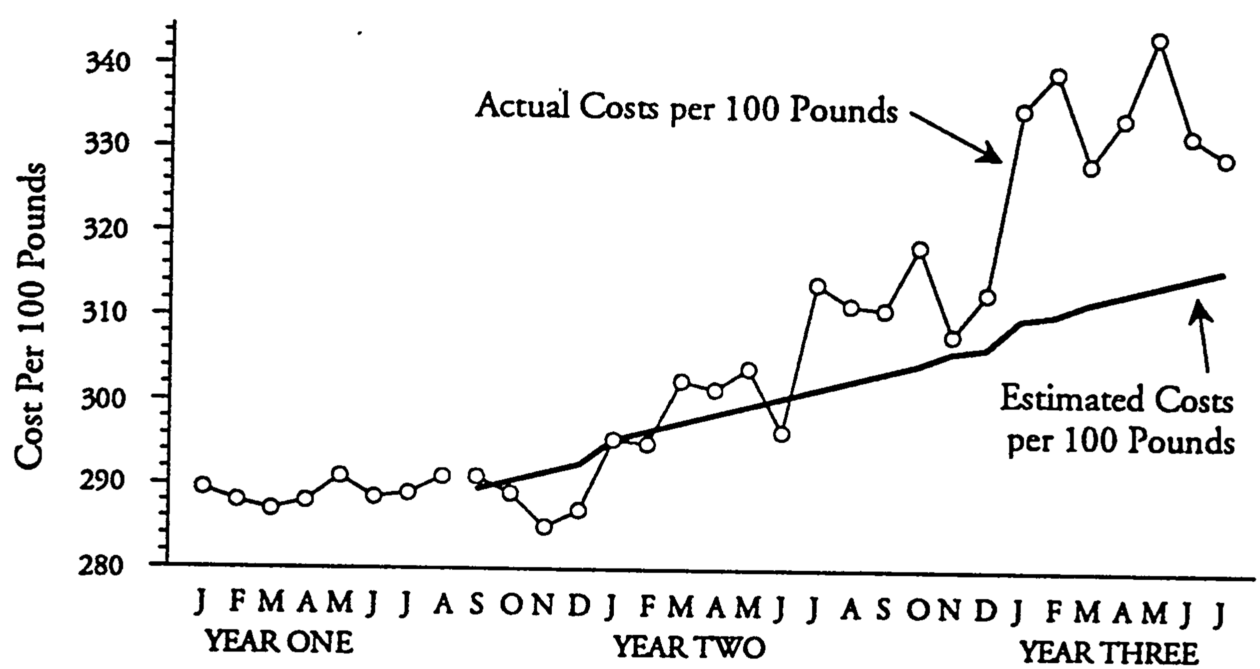

Figure 5.20: Actual Costs versus Estimated Costs

Estimated Total Production Costs
(per 100 pounds of usable product)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One	289.62	287.96	286.85	287.74	290.92	288.52	288.92	290.88	289.26	290.35	291.48	292.34
Two	295.25	296.40	297.41	298.38	299.61	300.54	301.36	302.31	303.41	304.62	305.89	306.31
Three	309.78	310.54	311.85	313.04	314.09	315.07	316.25					

Figure 5.21: Estimated Production Costs for Department 13

Therefore, the messenger who revealed the effect of all these "process improvements" soon took a job at another company.

There are several morals to this story.

- A manager must look at the whole picture, not just the narrow slices provided by the departmental figures. The artificial boundaries created by departments can distort both the data and the system.
- Good accounting practices for a whole company may be inappropriate when applied on a departmental level. Trying to micro-manage and micro-account can result in severe distortions of the data.
- When it comes to pleasing our customers, the important figures are unknown and unknowable. It is dangerous to run a company using only the visible figures.
- Some figures have the seeds of distortion built-in. One transportation department was tracking the "transportation utilization efficiency." If someone decided to make this number look better, they could simply wait until they had full loads before shipping any product. Of course this would have a negative impact upon the figures for on-time shipments, and would result in unhappy customers, but it would certainly make the utilization numbers look good.
- The optimization of each department will always result in a plant which is suboptimal. The optimization of the whole system will require that some departments be operated suboptimally. However, by encouraging competition between managers, most organizations make it impossible for departments to cooperate for the good of the company.

MANUAL METHODS

406. TEAR DOWN STAGING BRACKET ON BULKHEAD WITH WRENCH AT ANY TANKS ANI
VOIDS CARPENTER
PER STAGING BRACKET OFG: 3 05-FEB-82
REPRESENTS ELAPSED TIME
* REPRESENTS TEARING DOWN STAGING BRACKET
* ...IN ANY TANK. BRACKETS ARE LOWERED TO
* ...MATL-PILE BY WINCH.
* MAXIMUM NUMBER OF BRACKETS IN LIFT = 3
CARP-1 BEGINS AT BRKT-2

1 CARP-1 LOOSEN NUT AT BRKT-1 1 ARM-STROKE USING WRENCH-1 AND HOL
2 CARP-1 HOLD+LOOSEN NUT AT BRKT-1 13 WRIST-STROKES USING WRENCH-
ASIDE TO CARP-1
3 CARP-1 GET+REMOVE BOLT FROM BRKT-1 TO CARP-1
4 CARP-1 THROW NUT AND BOLT FROM CARP-1 TO MATL-PILE WITHOUT BENI
5 CARP-2 GET+PLACE BRKT FROM BRKT-1 TO BRKT-PILE
6 WINCH-OPER LOOSEN (=SWING) CABLE WITH BEND AT BTRWTH 5 ARM-S
USING HANDS F 1 / 3
7 WINCH-OPER THROW CABLE FROM BTRWTH TO CARP-2 F 1 / 3
8 CARP-2 GET+MANIPULATE WITH BEND CABLE AT BRKT-PILE (HOOK AROUI
BRACKETS) F 1 / 3
9 WINCH-OPER PUSH WINCH-FREE PROCESS (CLEAR OBSTACLES) F 1 / 3
10 WINCH-OPER PUSH WINCH-DOWN PROCESS (TO MATL PILE) F 1 / 3
11 WINCH-OPER PUSH WINCH-UP PROCESS (TO BTRWTH) F 1 / 3
12 CARP-2 AND CARP1 WALK TO BRKT-2

UNDERSTANDING THE TRADE DEFICITS

The U.S. Trade Deficits for the first ten months of 1987 are given in Figure 2.7. In this period the deficit got worse (increased) relative to the preceding month six times, and it improved (decreased) only three times.

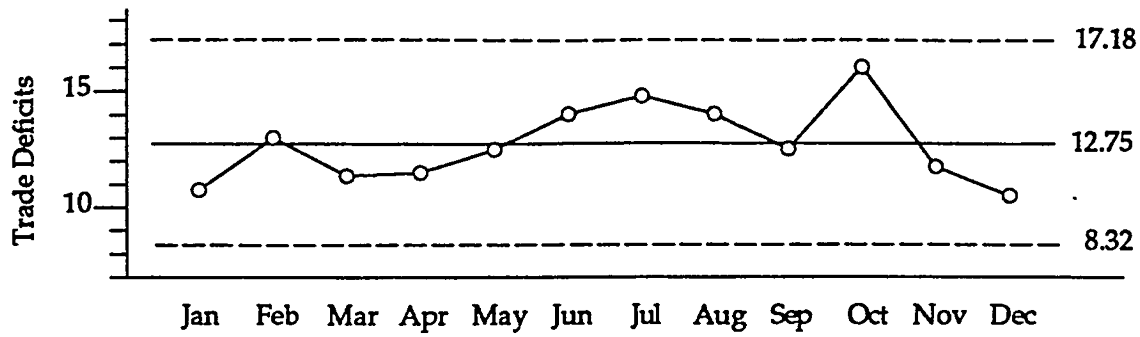

Figure 2.8: Control Chart for Monthly U.S. Trade Deficits in 1987

The average deficit for 1987 was 12.75 billion dollars. Using the technique which is described in the next chapter, it can be seen that, based on the amount of month-to-month variation, the deficit could vary from 8.32 billion to 17.18 billion without representing a real departure from the average of 12.75 billion.

The chart in Figure 2.8 shows no evidence of a sustained trend. The deficits are not systematically getting better, nor are they systematically getting worse. For the year as a whole, this chart shows no clear-cut evidence of change. Some months *appear* to be better than others, but this chart indicates that it will be a waste to analyze any one month to see what is different from preceding months. One should treat *all* the months of 1987 as if they came from the same system.

The data for 1988 are shown in Figure 2.9 below. These values could be plotted against the limits shown in Figure 2.8 above. This is done in Figures 2.10 and 2.11.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	10.0	11.4	7.9	9.5	8.0	11.8	10.5	11.2	9.2	10.1	10.4	10.5

Figure 2.9: Monthly U.S. Trade Deficits, 1988 ($ billions)

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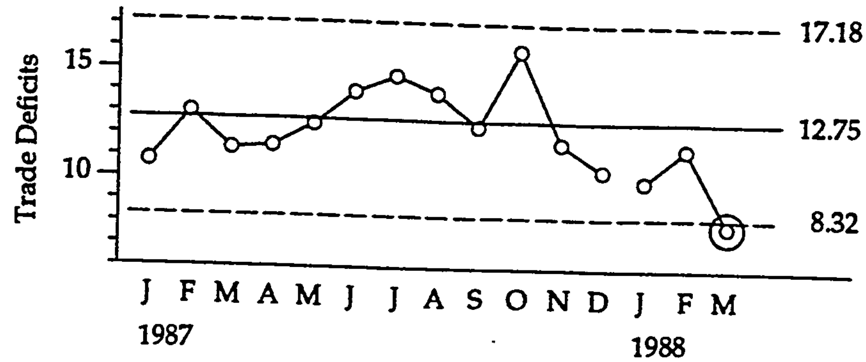

Figure 2.10: Control Chart for U.S. Trade Deficits, 1987-early 1988

Figure 2.10 shows that by March of 1988 there was definite evidence of an improvement in the deficit. The March value is below the lower limit of 8.32.

Before a single month can be said to signal a change in the time series that single value must go beyond one of the two limits. This happens in March of 1988. Now that one has definite evidence of a change, how does one interpret the chart? One method is to look at the sequence of points adjacent to the out-of-control point which are also on the same side of the central line as the out-of-control point. This sequence is shown in Figure 2.11. The interpretation of this sequence could be expressed as follows. A change is clearly indicated in March of 1988—it may have begun as early as November of 1987—and it continued throughout the rest of 1988.

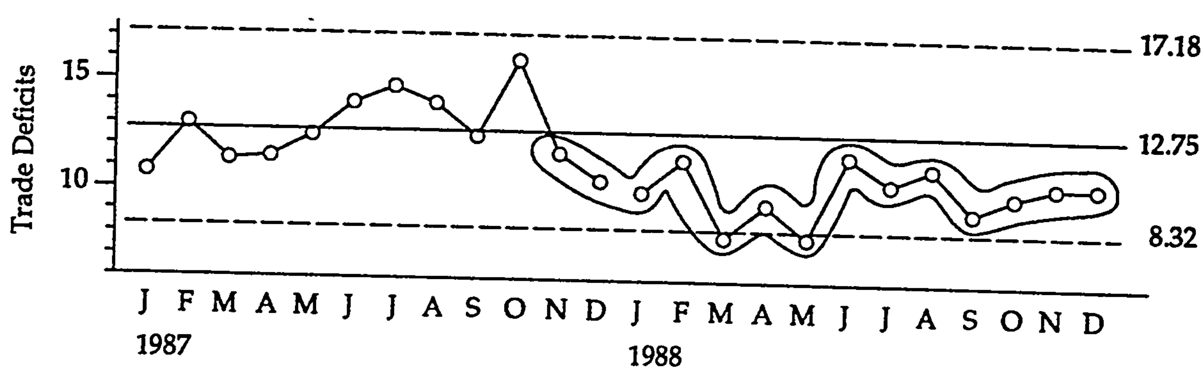

Figure 2.11: Control Chart for U.S. Trade Deficits, 1987-1988

Thus, there is definite evidence that the trade deficit improved dur 1988, compared with 1987. One could now re-compute limits for 19 and use them to evaluate further monthly values for signs of improv ment or deterioration.

THE SECOND PRINCIPLE FOR UNDERSTANDING DATA

Shewhart's Control Chart Approach to the analysis of data is m powerful than either the Specification Approach or the Average Va Approach. It also is fundamentally different. Instead of attempting attach a meaning to each and every specific value of the time series, control Chart Approach concentrates on the behavior of the underly process. It is, therefore, more fundamental and more comprehensi This is why the control Chart Approach yields more insight and grea understanding than the Specification Approach or the Average Va Approach.

The Control Chart Approach uses the time series to define the vo of the process. It also gives the user a way to know whether it is saf extrapolate into the near future. Moreover, whenever it is reasonable make this extrapolation, the control chart also defines the range of valu that one is likely to see in the near future. The Specification Approa and the Average Value Approach do none of these things.

The Control Chart Approach does all of these things because it tal variation into account. *Variation is the random aria' miscellaneous com nent that undermines the simple and limited comparisons.* The "nois introduced by variation is what confuses and clouds all compariso between single values. Until one can allow for the noise in a time seri one cannot fully understand just what may be indicated by a single val Is the current value a "signal" that something has changed, or does current value differ from the historic average by nothing but "noise

ACTIVITY BASED COSTING (ABC)

A METHOD OF MEASURING THE COST AND PERFORMANCE OF ACTIVITIES AND COST OBJECTS.

ABC EMPOWERS MANAGERS AND OTHER USERS WITH THE INFORMATION AND TOOLS TO IMPROVE BUSINESS PERFORMANCE

ASSIGNS COST TO ACTIVITIES BASED ON THEIR USE OF RESOURCES AND TO COST OBJECTS BASED ON THEIR USE OF ACTIVITIES

ABC RECOGNIZES THE CAUSAL RELATIONSHIP OF COST DRIVERS TO ACTIVITIES

ACTIVITY IS THE DESCRIPTION OF WORK THAT OCCURS IN AN ORGANIZATION AND CONSUMES RESOURCES

ACTIVITY BASED COSTING (Continued)

- COST OBJECT IS THE REASON FOR PERFORMING AN ACTIVITY SUCH AS TO MAKE A PRODUCT OR SERVE A CUSTOMER
- COST DRIVER IS AN EVENT OR CAUSAL FACTOR THAT INFLUENCES THE LEVEL AND PERFORMANCE OF ACTIVITIES AND THE RESULTING CONSUMPTION OF RESOURCES
- NON-VALUE ADDED ACTIVITY IS AN ACTIVITY THAT IS JUDGED NOT TO CONTRIBUTE TO CUSTOMER VALUE
- CONVENTIONAL COSTING SYSTEMS DO NOT ASSIST MANAGEMENT TO MAKE WORLD CLASS DECISION MAKING
- IN FACT, CONVENTIONAL COSTING METHODS OFTEN CAUSE THE WRONG DECISION TO BE MADE

ACTIVITY BASED COSTING (Continued)

- **CONVENTIONAL COST SYSTEM**

  BASED ON APPROACH THAT PRODUCTS CONSUME COSTS

  USES HISTORICAL AND DERIVED INFORMATION

  NOT SUITED TO MEASURING FLOW OF WORK WHICH MOVES ACROSS DEPARTMENT BOUNDARIES

- **ACTIVITY BASED COSTING**

  BASED ON APPROACH THAT ACTIVITIES CONSUME RESOURCES AND PRODUCTS CONSUME ACTIVITIES

  USES PREDICTIVE AND CAUSAL INFORMATION

  CAN BE USED TO MEASURE CROSS DEPARTMENT FLOW OF WORK

ACTIVITY BASED COSTING (Continued)

- EXAMPLES OF ABC TERMS

ACTIVITY	RELEASE ENGINEERING DRAWING
FUNCTION	ENGINEERING
PROCESS	DESIGN
ACTIVITY DEFINITION	THE PROCESS OF DESIGNING THE SYSTEM, SELECTING THE COMPONENTS, PREPARING AND ISSUING THE DRAWING
INPUTS	SPECIFICATIONS AND DESIGN STANDARDS
OUTPUTS	DRAWING
OUTPUT MEASURE	NUMBER OF DRAWINGS PER WEEK
COST DRIVER	QUANTITY AND QUALITY OF MATERIAL

ACTIVITY BASED COSTING (Continued)

- TRACE, ASSIGN AND RECORD ACTIVITY COST TO A PRODUCT
- IMPROVE COST BY IDENTIFYING NON-VALUE ADDED ACTIVITIES
- MAKE VISIBLE THE CAUSES OF COMPLEXITY THAT DOES NOT CONTRIBUTE TO CUSTOMER VALUE
- FOCUS AND MONITOR CONTINUAL COST IMPROVEMENT
- PROVIDE MEANINGFUL INFORMATION FOR PRODUCT DESIGN AND DEVELOPMENT DECISIONS

BY MIRRORING MANUFACTURING PROCESS, DESIGNERS AND PRODUCTION MANAGERS CAN EASILY DETERMINE HOW DESIGN CHANGES WILL AFFECT PRODUCT COSTS

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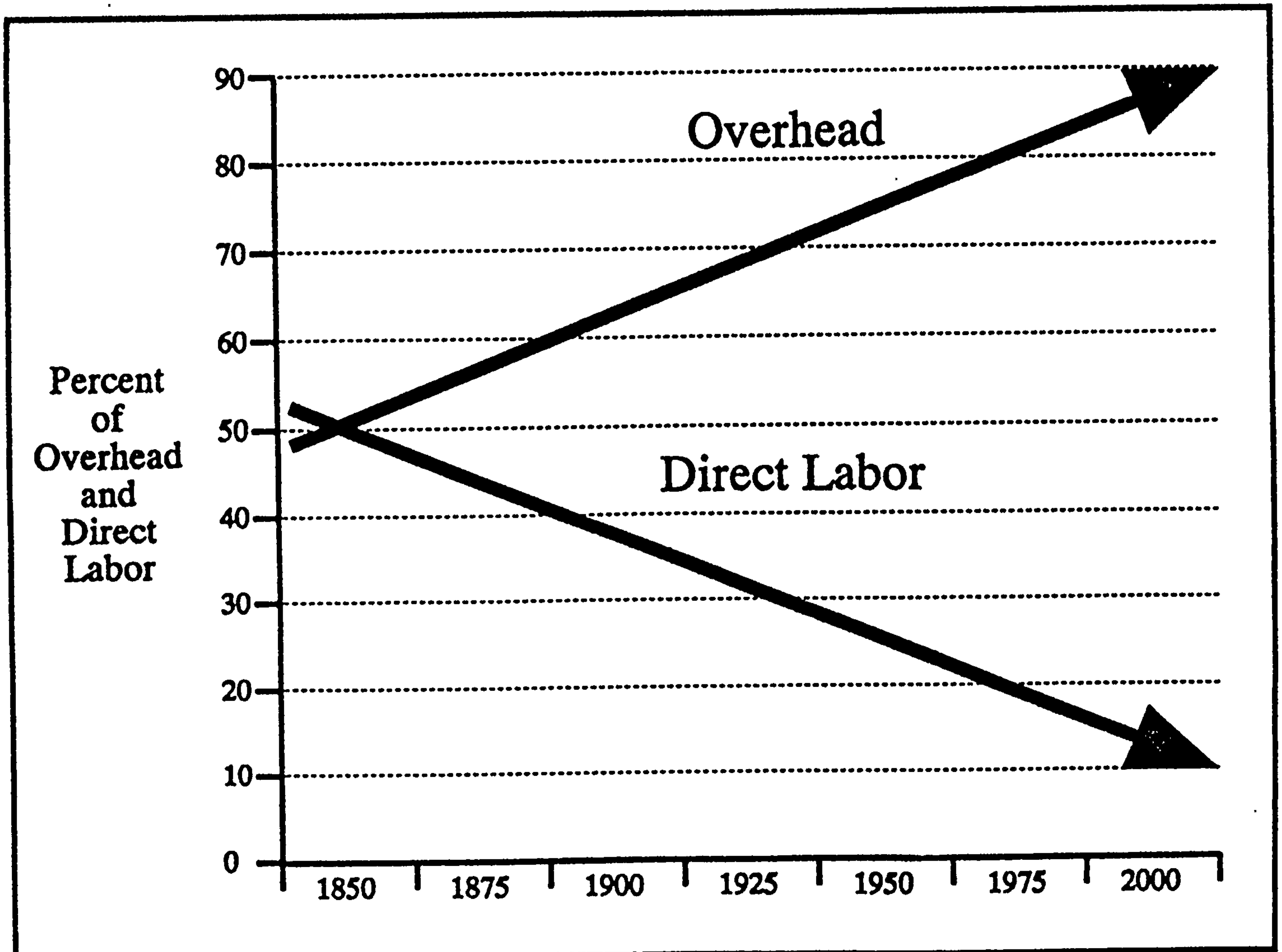

Figure 2-3. *The importance of overhead cost.* The relative importance of direct labor and overhead have changed over 150 years. Thus, the focus of yesterday's cost systems on direct labor must give way to cost systems that focus on overhead.

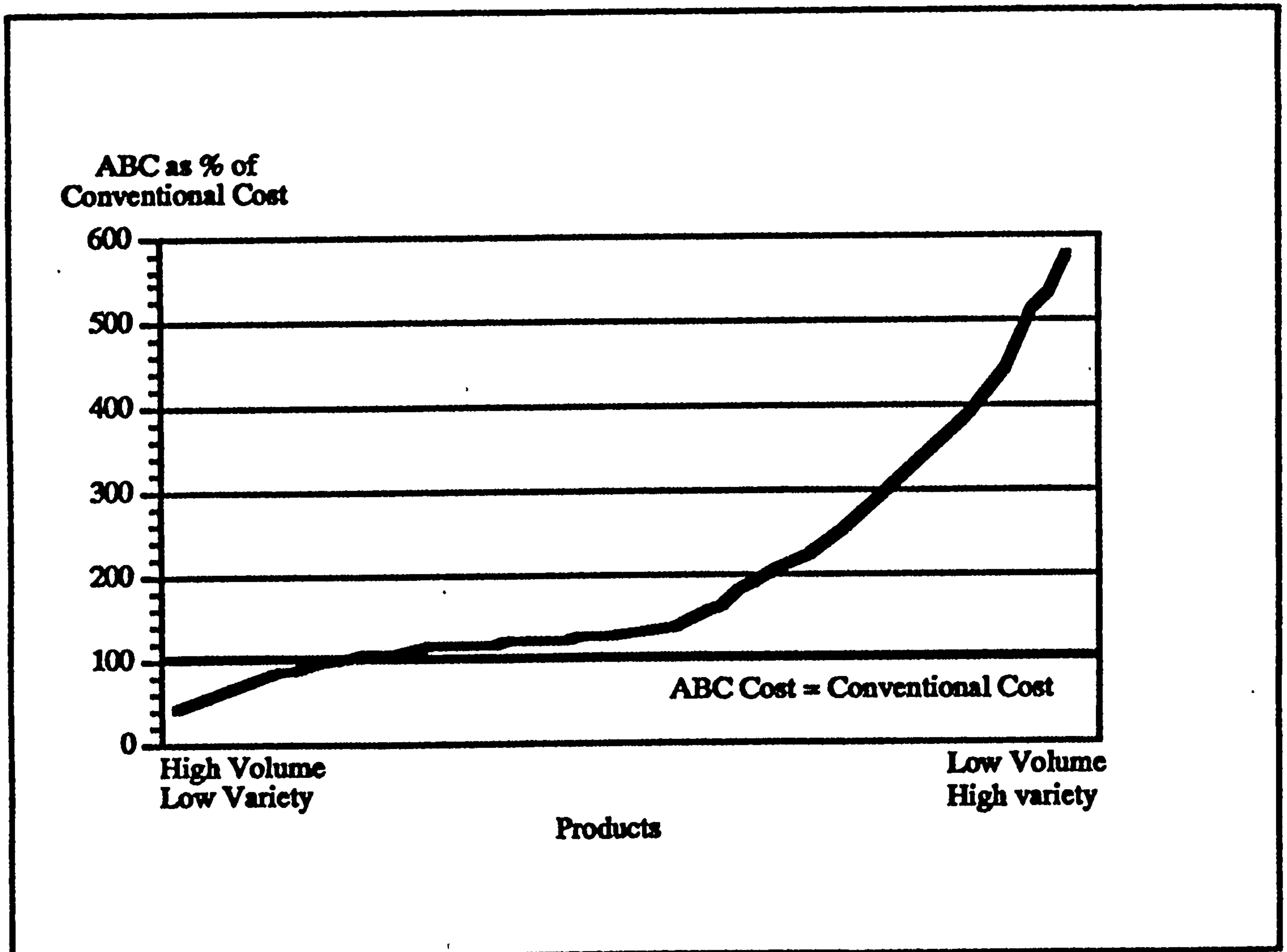

Figure 1-1. *ABC as a percent of conventional cost.* **Product costs reported by conventional systems often differ substantially from the more accurate activity-based costing (ABC) results, as shown in this comparative example from a Northern Telecom assembly plant. Using the conventional costing data can result in severe errors in product strategies.**

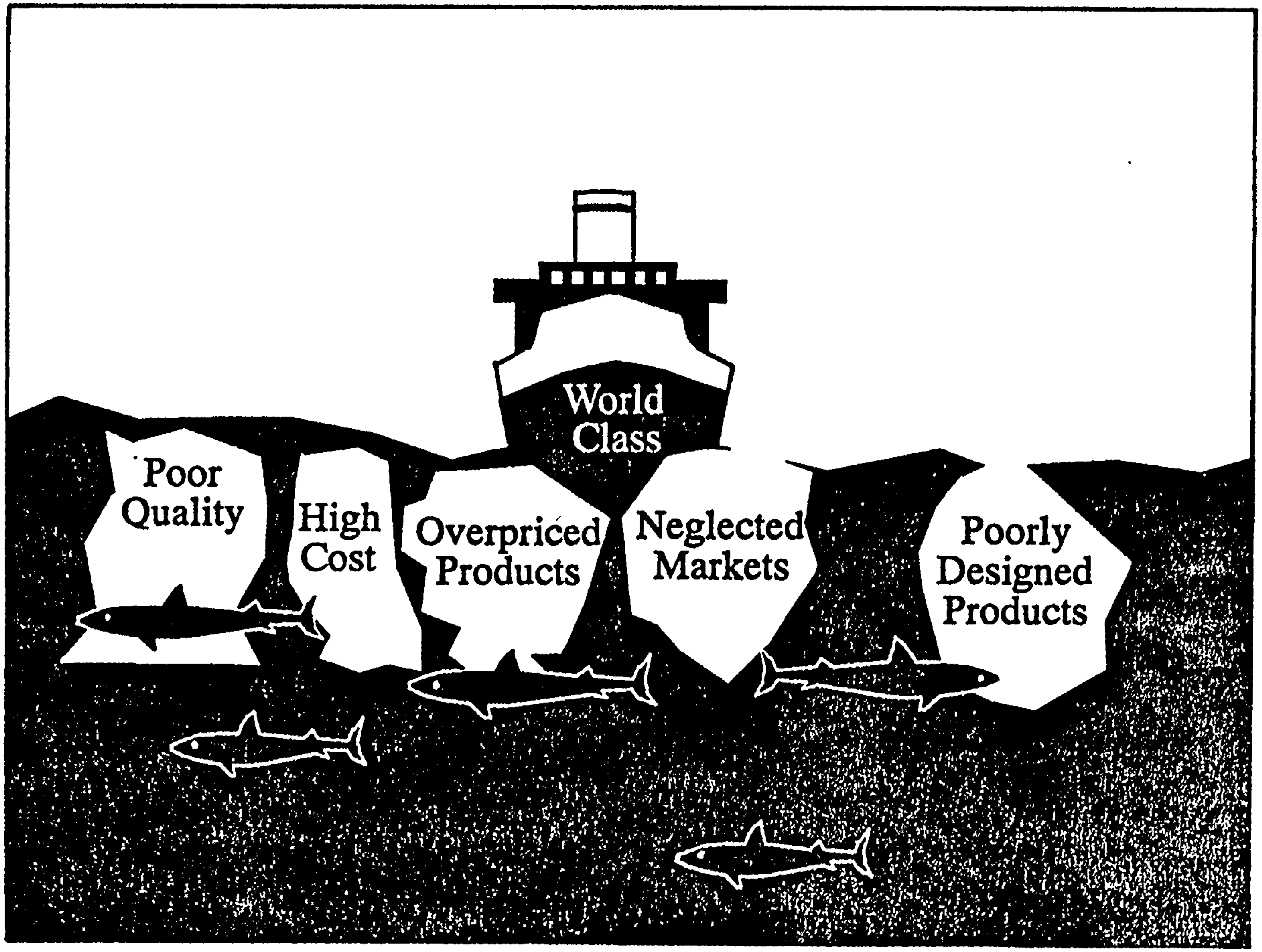

Figure 3-1. *Rocks and sharks.* Like submerged rocks, problems and opportunities are hidden from view. ABC information helps reveal and identify the problem rocks, improve competitive position, and avoid getting eaten by sharks.

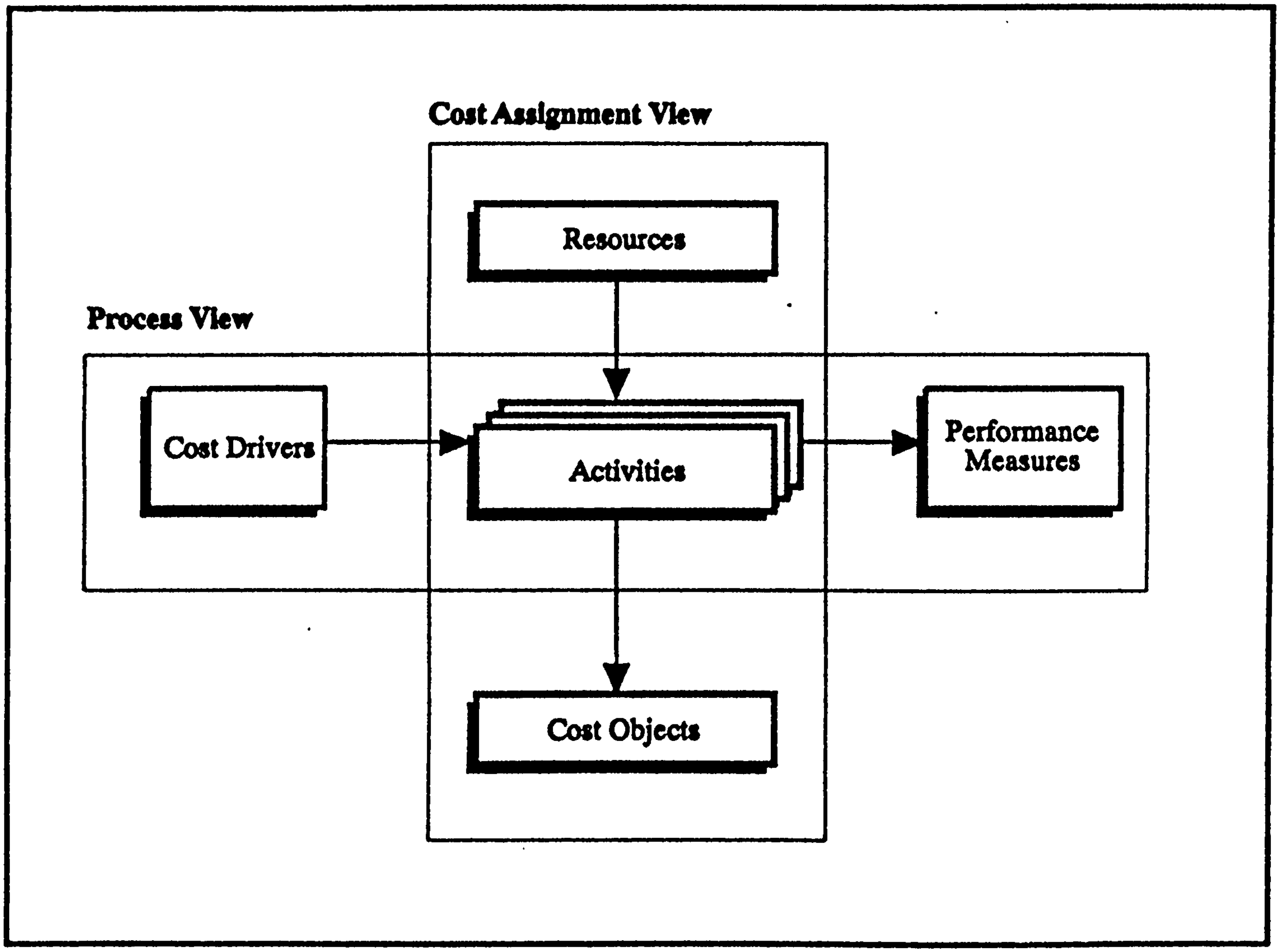

Figure 4-2. *The ABC model.* Activity-based costing has come a long way in a short period of time. Once thought of as just a better way of costing products, ABC now has more points of focus and additional uses. Cost and nonfinancial information work together to yield strategic and operational insights.

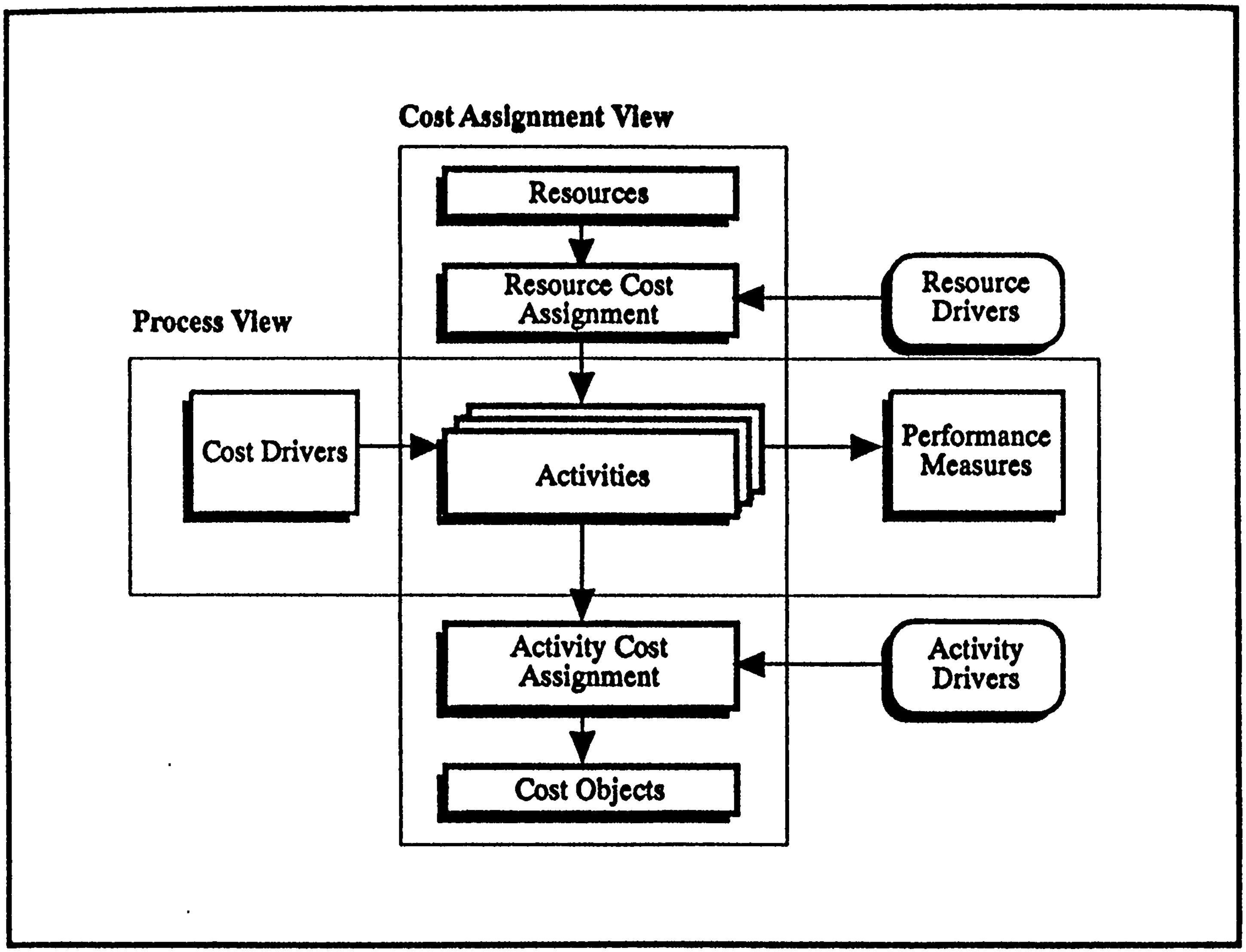

Figure 5-1. ***ABC building blocks.*** **Activity-based costing comprises several building blocks. The building blocks in the vertical dimension work together to assign cost from resources to activities and from the resources to the cost objects. The building**

GOES WITH ABC

Chapter 1

THE MOUNTING COMPETITIVE CRISIS

Selling something for less than it costs can be common sense. Or it can be the wrong move.

There are all kinds of "common cents" reasons for selling a product or service at a loss. Retailers, for example, often underprice a selected product temporarily. They use this underpriced product as a "loss-leader" to boost customer traffic through the store. The basic premise is that increased traffic generates greater overall sales volume.

Companies[*] may also use a similar underpricing strategy on a broader basis to establish, protect, or regain market share. It's common sense when it's well-informed and intentional—and when it works.

Unintentional losses, however, are always the wrong move. Nobody stays in business long by selling products for less than they cost. Yet this is exactly what more and more manufacturers ~~are doing with more and more of their products.~~

To put the problem into a dollar-and-cents perspective, consider this one simple example. It's one of many from companies that have implemented activity-based costing (ABC).

The company made a product at a cost of $2 per unit. Or, at least, that's the product cost the company's conventional costing system assigned. So management wisely priced the product for a nice "profit" at a competitive $4 per unit.

Get example of how this can be

But guess what. There was no profit on the product. In fact, each sale resulted in a $498 loss! It was as if the company was

2/3

* *Common Cents* applies to any organization, whether manufacturing, service.

wrapping dollar bills around the product each time it was shipped to a customer.

They had their priorities wrong. The company was devoting its energy to the wrong customer. The right customer was served by someone else.

The company was also devoting little effort to cutting the cost of this product. In reality, there were many opportunities to improve.

Now you are probably saying to yourself, “How could this be?

Simple. At a $4 price, the low sales volumes of this proc failed to cover its costs of production and distribution by a wide margin. A more appropriate *ABC* study revealed that the product actually cost $500-not $2-to make and distribute.

That’s a 25,000% product costing error!

It would be nice if this example was an isolated product costing aberration. But it’s not. Costing inaccuracies-and other strategic errors-are quite common when companies with a variety of products, or high overhead, use conventional cost systems. While these inaccuracies typically aren’t as dramatic as 25,000%, they can still be quite significant.

The curve in *Figure 1-1* shows a profile common to many companies. Notice that the “true” cost of many products-primarily the low-volume, high-variety ones-is 1% to 600% greater than the conventional cost. High-volume, lower-variety ones error in the other direction. Their “true” cost drops by 10% to 80%, which is perhaps an even more significant correction for highly competitive

TOTAL BO

Substantial costing inaccuracies in either direction lead to unintentional competitive mistakes. Pricing errors lead to economic losses. Producing and selling the wrong products (to the wrong customers) weakens the company in the marketplace. Focusing cost reduction efforts on the wrong products and the wrong costs makes it difficult to compete with low-cost offshore producers.

You can’t afford competitive mistakes-especially in today’s global economy. You need every advantage you can get to compete with Japanese, German, and other tough competitors, including U.S. companies. Cost systems that send you the wrong signals can put you on a crisis course from which recovery is difficult.

cost. Each time a unit of the product is manufactured, it's assumed that cost is incurred.

This assumption does make sense for certain types of cost. For example, the cost of activities performed directly on the product unit, such as direct labor, fits this assumption.

Direct labor activities are performed directly on a valve, housing, circuit board, or other product unit. If the number of units produced goes up, more units must be assembled, and the cost of direct labor will go up, too.

The assumption doe not work, however, with activities that aren't performed directly o the product units. For example, some activities are performed on batches of products. When you set up a machine to produce a type of products you produce a batch of the parts rather than an individual unit. Conventional cost systems deal with units, *not* batches.

Other activities are performed by product type. When you change engineering specifications on a product, for example, all future product units are affected, *not* just a single unit. Again, this doesn't into the unit methodologies and assumptions o conventional costing.

The correct assumption-one that fits what's really happen-ing-is that activities cause costs, and products (and customers) create the need to perform activities. But this assumption reruires a very different type of cost system, as the next Chapter shows

or now, let's continue our investigation of why conventional cost systems report inaccurate product costs. Fundamentally, it's because they try to assign cost directly to product units rather than to activities first, then from activities to product units.

Figure 2-2 is a case in point. Products A and B are different. Product A is a mature product. Its technology is quite simple. As a result, it requires little inspection effort. But it does require quite a lot of direct labor for assembly

In contrast, Product B is a new product. It's a complex product that requires a lot of inspection time, though the amount of labor required to assemble it is less.

The conventional cost system assigns overhead cost to Products A and B using direct labor hours. Direct labor hours is a measure of activity that is performed directly on each unit of A and B. It's also a commonly used costing measure in conventional cost systems.

Product A
100 units
1 inspection hr.
3 direct labor hrs.

Product A
Labor ~~*Conventional:*~~
3 x $120 = $360/100 = $3.60
O/H *ABC:*
1 x $100 = $100/100 = $1
ABC = 4.60
O/H Traditional 3 x 100/100 = $3

Product B
100 units
5 inspection hrs.
2 direct labor hrs.

Product B
Labor ~~*Conventional:*~~
2 x $120 = $240/100 = $2.40
O/H *ABC:*
5 x $100 = $500/100 = $5
ABC = 7.40
O/H Traditional 2 x 100/100 = 2

Inspection Overhead = $600
Cost per direct labor hour = $120
Cost per inspection hour = $100

Figure 2-2. ***Conventional costing breaks down when products differ.*** **Direct labor hours, for example, *do not* accurately measure the cost of inspecting Products A and B.**

The problem here is that inspection effort is determined by the relative complexity of the products, not by the amount of direct labor. In fact, direct labor is negatively correlated with complexity in this example.

Product A, the simpler product, requires less inspection effort than B, but more direct labor time. Product A is, therefore, overcosted in the conventional cost system. Product B, which requires more inspection effort but less direct labor time, is, therefore, undercosted.

What if we assign cost based on the number of inspection hours? Would that be a better measure?

The number of inspection hours required for each product measures the inspection effort directly. Thus, it provides a more accurate measure of how each product consumes the cost of this activity. (Inspection hours provides an example of the type of measure used in activity-based costing, or ABC, as the next Chapter explains.)

The extent of conventional costing inaccuracy can be demonstrated by calculating the inspection cost of each product. The results of this are shown in *Figure 2-2*. Notice that Product A's cost falls by 72%, and Product B's cost increases by 108%. The

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relative cost of the two products is the reverse of what it was before.

The example in *Figure 2-2* is typical of the inaccuracies reported by conventional cost systems. When inaccuracies are removed by introducing an ABC system, it's quite common to see shifts in cost ranging from drops of 10% to 30% to increases of several hundred (or even thousands) of percent. Not surprisingly, such large shifts in cost lead to drastic reappraisals of product mix and pricing strategy.

Is it better to be reasonably right, or precisely wrong? If you use a conventional cost system, it may be hard to believe that *your* product costs are inaccurate by such orders of magnitude. But it's probably true.

Conventional cost systems often report the cost of products to fractions of a penny. For example, the cost of a product may be reported as $5.258637. Carrying product costing to such precision is a tribute to the power of computers and the accountant's traditional desire for exactness.

It's a brave manager who challenges the accuracy of such a precise number. *But keep in mind that precision doesn't necessarily mean accuracy.* Computers always compute with great precision. But if you put in inaccurate numbers or use the wrong computational methodology, all you get is precision without accuracy.

So how much should you trust the $5.258637 that your conventional cost system gives you? Too often the first digit is wrong. Worse yet, the decimal point is often in the wrong place, too.

Which companies are most likely to have large inaccuracies in reported product costs? It's those with large amounts of overhead and high diversity.

In recent years, the importance of overhead has increased tremendously. Knowledge workers, particularly engineers and software specialists, have displaced much of the direct labor force in many plants. In some cases, overhead outside the plant—engineering, marketing, and distribution—has increased to where it exceeds direct labor. *Figure 2-3* illustrates this trend.

The more overhead there is, the greater the chance for 217
distortion in reported costs. As a rule of thumb, overhead that

PRODUCT A

100 UNITS

USE OF O/H $100

3 DIRECT LABOR HOURS

PRODUCT B

100 UNITS

USE OF O/H $500

2 DIRECT LABOR HOURS

$\boxed{\text{CONVENTIONAL COSTING}}$

Labor	3 x 120	$360
O/H	3 x 120	$360
TOTAL		$720

OR $7.20 EACH UNIT

Labor 2 x 120 = $240

O/H 2 x 120 = $240

TOTAL $480

OR $4.80 EACH UNIT

$\boxed{\text{ABC}}$

Labor	3 x 120	$360
O/H		$100
TOTAL		$460

OR $4.60 EACH UNIT

	$240
	$500
TOTAL	$740

OR $7.40 EACH UNIT

SO IF YOU SOLD MORE OF B THAN A YOU WOULD BE LOSING MONEY. THIS MEANS THAT DECISION OF QUANTITIES OF A & B WOULD BE INCORRECT BASED ON TRADITIONAL COSTING

WHAT IS CONCURRENT ENGINEERING?

Concurrent Engineering (CE) is a misnomer in that it has always covered more than "engineering." At its outset it was the concurrent design of the product and its manufacturing processes. It has grown to include all product processes from the cradle to the grave.

Like Just-In-Time, CE is a philosophy not a technology. It uses technology to achieve its goals.

The main objective of CE is to shorten time from order to delivery of a new product at lowest cost and highest quality. It does this by using a parallel rather than sequential process for the different functional parts of the product design. This is accomplished through the use of multi functional teams.

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Designing new products

Cost drivers
- number of customer specifications
- classification of products

Performance measures
- number of tangible shapes
- number of changes in shapes
- average design time

Designing new tools

Cost drivers
- number of new shapes
- number of changes in shapes
- classification of products
- volume of production

Performance measures
- number of changes in specifications
- number of new drawings
- average design time

Manufacturing new tools

Cost drivers
- number of new drawings
- classification of products
- number of changes in specifications

Performance measures
- number of tools
- number of changes in tools
- elapsed tooling manufacturing time

Figure 4-6. *A product development process at Dayton Extruded Plastics.* These three activities work together to develop products and related tooling to meet customer specifications. The performance of each activity is linked by common cost drivers and performance measures.

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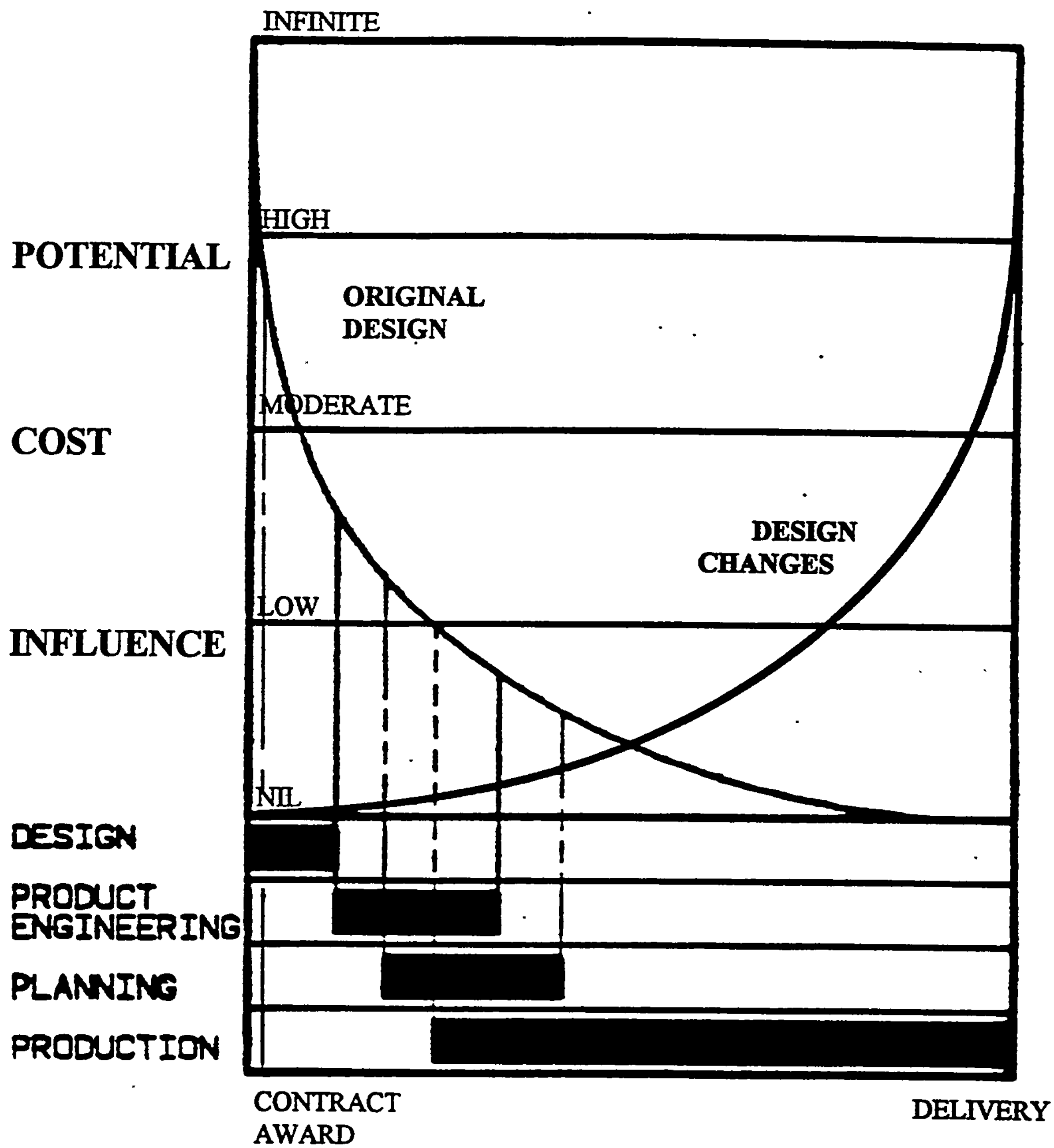


SHIP PRODUCTION PHASE

Design/Production Phase Cost Influence

WHAT IS CONCURRENT ENGINEERING?

The generally accepted definition of CE was prepared for the Institute of Defense Analysis (IDA) in 1986, and is:

Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements.

WHAT IS CONCURRENT ENGINEERING?

The definition which I like was given to me by Dr. Ralph Wood and is:

> *All functions work as a team in parallel, plan early, validate often and maintain oversight of product life cycle decisions within their control*

Another simple definition, also from Dr. Ralph Wood is:

> *Concurrent Engineering is systems engineering performed by cross functional teams*

CE is customer, process and team focused. While "customer" obviously means the purchaser and user of the product, it also means the company internal users of the output from the different process involved in producing the product.

DEFINITIONS

DESIGN

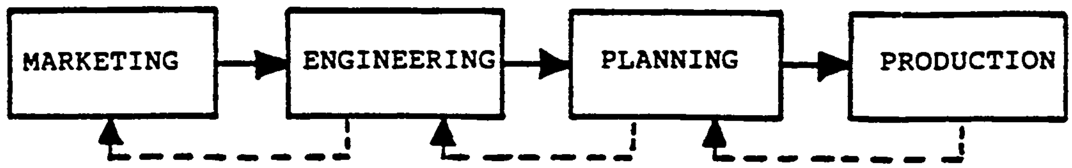
INTEGRATION OF A PRODUCT'S LIFE CYCLE ATTRIBUTES

PROCESS

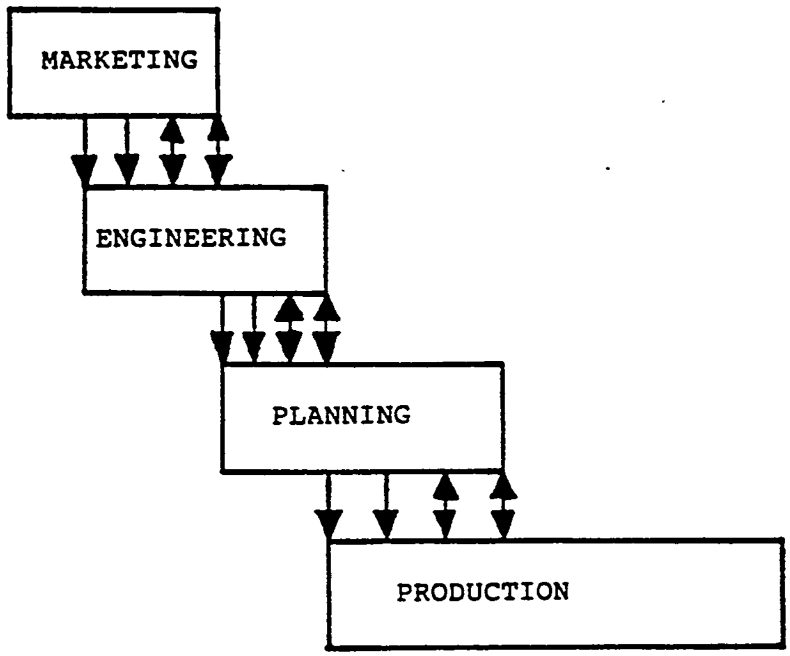
AN ORDERED SEQUENCE OF STEPS PERFORMED FOR A GIVEN PURPOSE, SUCH AS MATERIAL ORDERING PROCESS

METRIC

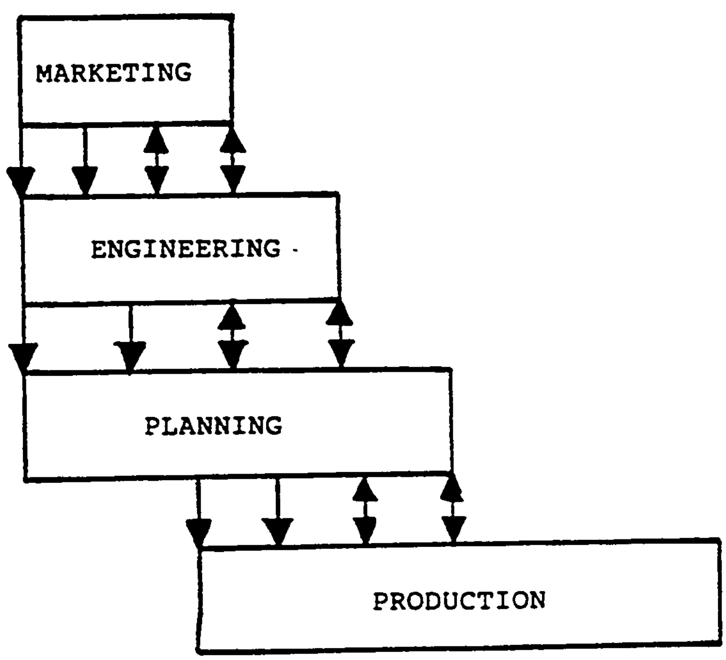
A QUANTITATIVE MEASUREMENT OF A SYSTEM, COMPONENT OR PROCESS TO DETERMINE THE DEGREE TO WHICH IT POSSESSES A GIVEN ATTRIBUTE



(a) Sequential



(b) Overlapping



(c) Parallel

Figure 2.1 - Product Design Processes

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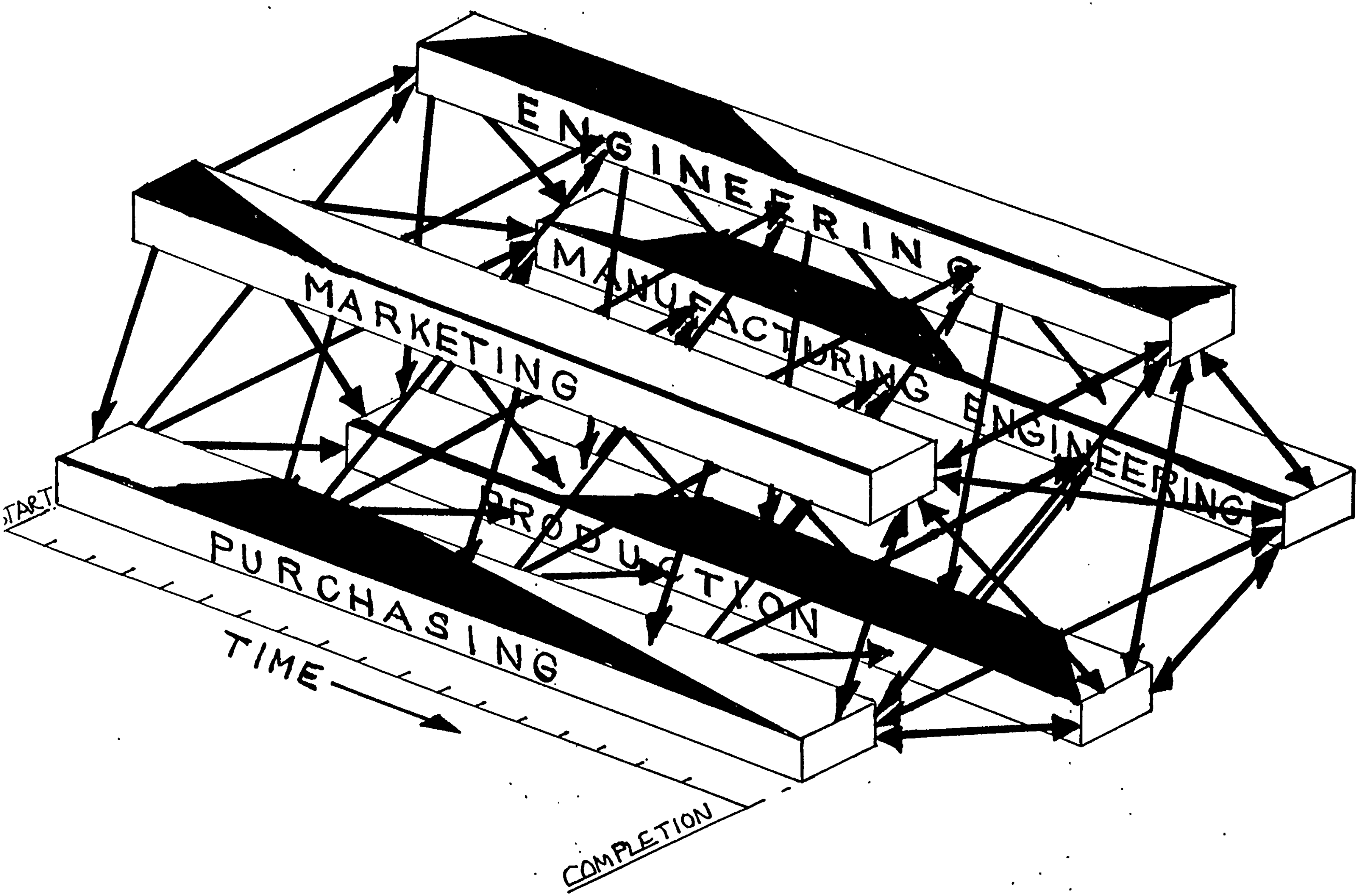
ENGINEERING
MANUFACTURING ENGINEERING
MARKETING
PRODUCTION
PURCHASING
START
TIME
COMPLETION

CONCURRENT ENGINEERING

WHATS IN A NAME?

CE

IPPD

IPDE

SE

IPT

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CE IS NOT NEW

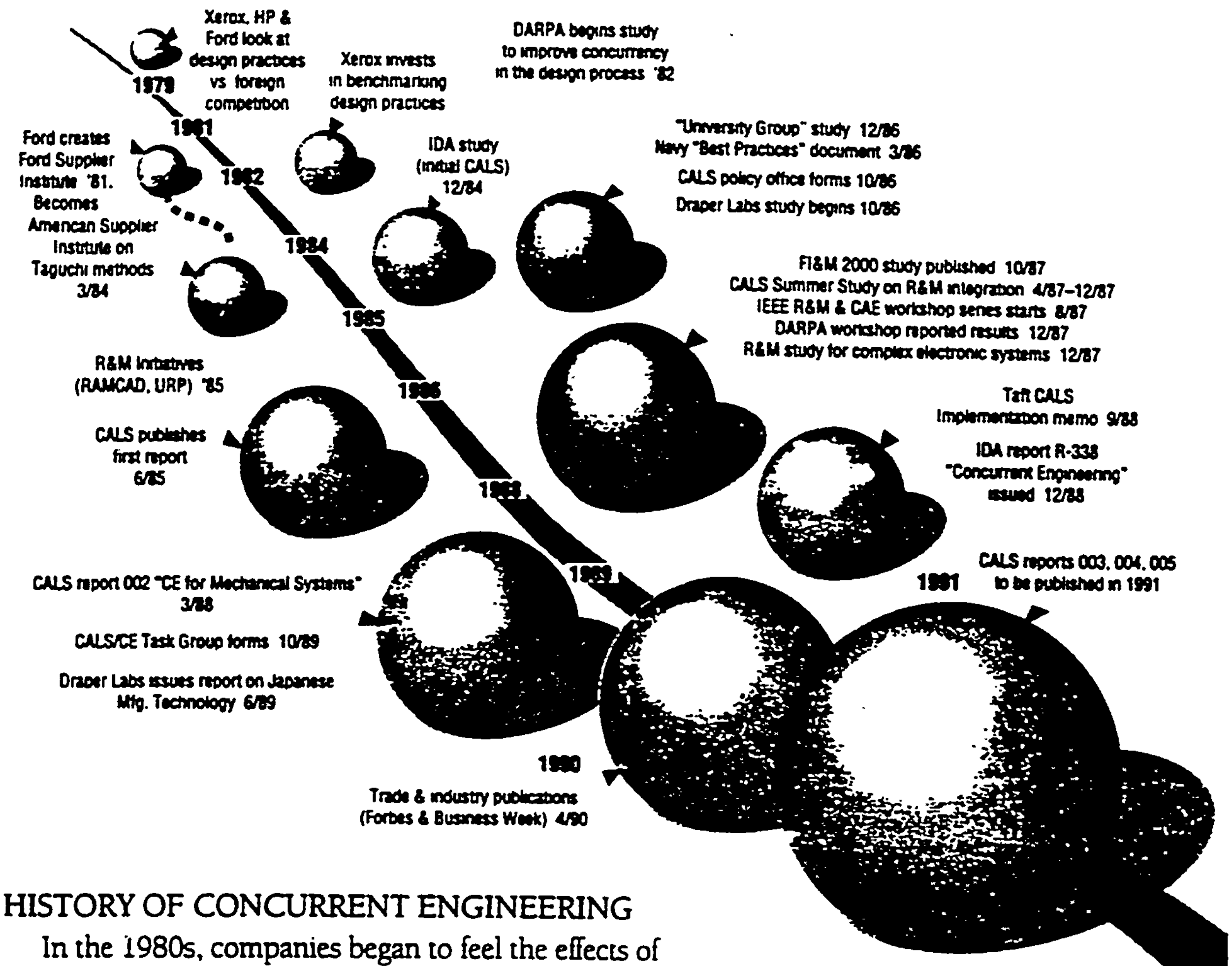
HAS BEEN USED BY MANY COMPANIES IN MANY INDUSTRIES TO VASTLY IMPROVE PERFORMANCE

IS IMPLEMENTED BY MANY COMPANIES BECAUSE THEY NEEDED TO CHANGE TO SURVIVE

Introduction

Concurrent engineering isn't new. Many companies will argue that they have been practicing concurrent engineering for a long time, and to varying degrees, they are right.

Concurrent Engineering Time Line



HISTORY OF CONCURRENT ENGINEERING

In the 1980s, companies began to feel the effects of three major influences on their product development:

- Newer and innovative technologies
- Increasing product complexities
- Larger organizations

Companies were forced to look for new product development methods. One of the most significant events in the concurrent engineering time line took place in 1982, when the Defense Advanced Research Projects Agency (DARPA) began a study to look for ways to improve concurrency in the design process. Five years later, when the results of the DARPA study were released, they proved to be an important foundation on which other groups would base further study.

MANUAL METHODS

CARPENTER
PER AERIAL PLATFORM OFG: 4 27-MAY-83

CUSTOMER FOCUSED

PROCESS FOCUSED

CROSS-FUNCTIONAL TEAMS

COLLABORATION

INTEGRATED AND CONCURRENT PERFORMANCE

CUSTOMER FOCUSED

CUSTOMER IS ANYONE INVOLVED IN THE PROCESS

A CUSTOMER IS USUALLY ALSO A PRODUCER

IN THE CE ENVIRONMENT SOME PEOPLE PREFER TO USE STAKEHOLDER THAN CUSTOMER TO AVOID OBVIOUS CONFUSION

PROCESS FOCUSED

THE DESIGN OF THE PROCESSES REQUIRED TO ENGINEER, MANUFACTURE, TEST AND SUPPORT THE PRODUCT ARE DEVELOPED ALONG WITH THE DESIGN OF THE PRODUCT THUS ASSURING THAT PROCESS NEEDS ARE CONSIDERED IN THE DESIGN RIGHT FROM DAY ONE

C R O S S - F U N C T I O N A L T E A M S

(Working with allies, enemies and other strangers. ***Glen Parker***

A TEAM COMPOSED OF INDIVIDUALS FROM DIFFERENT DEPARTMENTS (SKILLS) WITHIN A COMPANY WHOSE CONTRIBUTIONS ARE ESSENTIAL IN ACHIEVING OPTIMAL PRODUCT DEVELOPMENT

CROSS-FUNCTIONAL TEAMS SUCCESSFULLY COMBINE SKILL-SETS THAT NO SINGLE INDIVIDUAL POSSESSES

CROSS-FUNCTIONAL TEAM MEMBERS ARE OF EQUAL STATUS IN THE TEAM AND ARE REQUIREDED TO PARTICIPATE NOT MERELY ATTEND

C O L L A B O R A T I O N

(Shared Minds)

C O M M U N I C A T I O N

C O O P E R A T I O N

COMPLETE SHARED INFORMATION

INTEGRATED AND CONCURRENT PERFORMANCE

INVOLVES ALL PRODUCT AND PROCESS DEVELOPMENT PARTICIPANTS, INCLUDING INTERNAL AND EXTERNAL CUSTOMERS:

- **FINAL USER**
- **MARKETING**
- **DESIGN**
- **PLANNING**
- **SUPPLIERS**
- **PRODUCTION**
- **TEST**

IN A TEAM ENVIRONMENT FROM START TO FINISH OF THE DESIGN OF THE PRODUCT AND ITS MANUFACTURING PROCESSES

CRITICAL ELEMENTS OF CONCURRENT ENGINEERING

Customer Focus	- Understanding of the customer requirements and expectations - Methodology to capture and deploy customer requirements - Constant attention to customer satisfaction; and - Rapid assessment and accommodation of new priorities
Process Focus	- Documentation of process capabilities and metrics - Understanding of the value chain and linkages with the customer and supplier value chains - Modeling of process work flows - Identification and control of critical process events and parameters; and - Relentless pursuit of process improvement
Strategies for team formation and development	- Representation of all relevant (internal & external) life cycle perspectives in the product development process from the early stages, - Rational for team assignment - Team training - Team launch procedures - Team performance measures
Accommodation of teams within the organization	- Physical or virtual collocation - Career paths for members of cross functional teams - Team recognition and incentives - Management directive describing team responsibilities, authority, and accountability - Operation of teams as strategic business units in organization's value chain; and - Removal of organizational barriers to effective teamwork
Management systems	- Risk (uncertainty) management - Integrated master planning and scheduling - Value based resource allocation - Cost/schedule control systems - Technical performance monitoring; and - Program based budget authority
Mechanism for rapid product assurance	- Adoption of standards - Adoption of robust design principles - Application of computer aided design and simulation tools; and - Use of rapid prototyping tools - Adoption of off-line and on-line quality control methods
Agility	- Ability to respond gracefully to change - Effective use of technology - Corporate memory
Leadership of senior management	- Leadership role model - Commitment to the resolution of issues at the lowest level - Commitment to support CE throughout the transformation cycle; and - Relentless pursuit of improvement - Resource allocation
Discipline	- Training, experience, practices that correct, mold, strengthen, or perfect - Systematic, willing, and purposeful attention to assigned tasks - Collective, shared approaches to problems and decisions - Common methodologies, measures, knowledge for approaching tasks

CRITICAL ELEMENTS OF CONCURRENT ENGINEERING

IN ADDITION TO THE CRITICAL ELEMENTS LISTED IN THE TABLE THERE MUST BE ENABLING TECHNOLOGIES SUCH AS SYSTEMS AND TOOLS FOR:

- **THE SHARING OF INFORMATION.**
- **COMMUNICATING.**
- **COORDINATING.**
- **CAPTURING DESIGN HISTORY.**
- **INTEGRATING COMPUTER TOOLS AND DATABASES.**

ANOTHER CRITICAL ELEMENT IS THE ABILITY TO CAPTURE AND DOCUMENT CURRENT PRODUCT CHARACTERISTICS, PROCESSES AND COMPANY ORGANIZATION (STRUCTURE AND POLICIES). THEN IT MUST BE POSSIBLE TO DEVELOP THE DESIRED PRODUCT CHARACTERISTICS, PROCESSES AND THE REQUIRED ORGANIZATION.

THAT IS, WHAT AND HOW THINGS ARE DONE TODAY AND WHAT AND HOW THEY SHOULD BE DONE IN THE IMMEDIATE FUTURE. THIS IS ESSENTIAL IF ANY IMPROVEMENT IS TO BE ACHIEVED.

WHY USE CONCURRENT ENGINEERING

To successfully enter the global commercial shipbuilding market U.S. shipbuilders must change their approach to enable them to produce a high quality, competitive cost ship in the shortest possible time.

Cost reductions of 30 to 50% and similar design and build cycle reductions are necessary.

While the introduction of improved shipbuilding techniques, such as zone design and construction, and improved shipbuilding process by utilizing the Build Strategy approach, have resulted in a narrowing of the gap between U.S. and best foreign shipbuilders, they are not enough.

They are simply trying to catch up with a moving target. Something needs to be done to propel the U.S. shipyards to at least the level of the best competition and then to find and sustain a competitive advantage over them.

CONCURRENT ENGINEERING BENEFITS

DEVELOPMENT TIME	30 - 70%	REDUCTION
ENGINEERING CHANGES	65- 90%	REDUCTION
TIME TO MARKET	20 - 90%	REDUCTION
OVERALL QUALITY	200- 600%	IMPROVEMENT
PRODUCTIVITY	20 -110%	IMPROVEMENT
DOLLAR SALES	5- 50%	IMPROVEMENT
RETURN ON ASSETS	20 - 120%	IMPROVEMENT

MAJOR CHALLENGES

CE DEMANDS SIGNIFICANT AND FUNDAMENTAL CHANGE IN THE WAY PRODUCT DEVELOPMENT IS MANAGED

MANAGERS PREVIOUS EXPERIENCE PROBABLY HAS NOT PREPARED THEM FOR SUCH A CHANGE

WHILE THE USE OF CE IS INCREASING, THE TRADITIONAL “PASS IT OVER THE WALL” APPROACH TO PRODUCT DEVELOPMENT IS STILL THE MOST COMMON

MAJOR CHALLENGES (Continued)

CE TYPICAL CHANGES REQUIRE MOVING FROM:

- DEPARTMENT FOCUS TO COMPANY FOCUS
- DIRECTED INDIVIDUALS OR GROUPS TO COACHED TEAMS
- INDIVIDUAL INTERESTS TO TEAM INTERESTS
- AUTOCRATIC MANAGEMENT TO LEADERSHIP WITH EMPOWERED FOLLOWERS
- DICTATED DECISIONS TO CONSENSUS DECISIONS

IS IT RIGHT FOR YOU?

CE IS NOT IMPLEMENTED EASILY

IT REQUIRES SUCH A SIGNIFICANT EFFORT AND CHANGE BY ALL LEVELS OF MANAGEMENT AND EMPLOYEES THAT IT IS SAFE TO SAY THAT IT IS NOT SUITABLE FOR EVERYONE

IF A COMPANY HAS TRIED TO IMPLEMENT TQM AND FAILED, THEN CE IS PROBABLY NOT FOR THEM EITHER

ARE YOU READY?

ONCE THE DECISION IS MADE TO IMPLEMENT CE IT IS NECESSARY TO SEE IF THE COMPANY IS READY

IS THE COMPANY CULTURE, PRACTICES AND TECHNOLOGY SUITABLE FOR THE TRANSFORMING CHANGES THAT ARE REQUIRED?

A NUMBER OF ASSESSMENT TOOLS HAVE BEEN DEVELOPED TO ASSIST COMPANY'S TO DETERMINE IF THEY ARE READY

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2. CE READINESS ASSESSMENT

Successful CE implementation requires the commitment of the managerial and technical staff. Once the commitment to CE is made, a strategy may be charted. The first step in this strategy is the assessment of the current status of the organization vis-a-vis the management practices and organizational culture and the state of the enabling technology. This is the aim of conducting a CE readiness assessment with process and technology components.

A number of assessment models already exist in literature:

- Software Engineering Institute's (SEI) Capability Maturity Model (CMM) [3,4];
- CALS/CE Electronic Systems Task Group's CE readiness assessment [5];
- Mentor Graphics Approach to CE readiness assessment [6];
- Malcolm Baldrige National Quality Award Criteria for organizational assessment [7]; and
- Navy's Best Practices Templates [8].

SEI's CMM model defines five levels of process maturity and may be used for process capability analysis and process maturity assessment. This model is specific to software engineering, does not emphasize technology, and does not include quantifiable metrics as part of the assessment model. The CALS/CE model defines four levels of organizational improvement and follows a two step process. In the first step, the CE needs of an organization are determined based on nine influencing factors. Then, the attributes of the CE approach needed are determined - this involves looking at four categories, organization, communication infrastructure, requirements, and product development methodology. The

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CALS/CE model is quite cumbersome and no clear distinction is made between process issues and technology issues. Mentor's approach incorporates assessment as well as specification of a CE implementation plan. An assessment is conducted along the same four dimensions as the CALS/CE group's approach. A "Methods matrix" is then applied to determine an organization's CE needs. This is followed by creating a "Dimensions map" that highlights the differences between the existing status and the needs. Then, the "Priority roadmap" helps in configuring an implementation plan. In the Total Quality Management (TQM) arena, the Baldrige criteria are used for an assessment and these focus on Leadership, Process, Customer satisfaction, etc.. The Navy's Best Practices Template focuses on the defense acquisition and production process.

The approach developed at CERC, and presented next synthesizes ideas from all the above assessment mechanisms. CERC's model is intended to be product independent.

2.1 Process Assessment

Based on the Software Engineering Institute's software engineering process maturity model [4], a five stage CE Process Maturity Model is postulated. Process maturity indicates the quality of the process and the consistency with which it is applied. The five stages[1] of CE process maturity are listed and briefly described in Table 1. The five stages are further qualified in Appendix A. The characteristics corresponding to the different types of teams are defined and elaborated upon in [9].

1. Ad-hoc	This stage is characterized by ill-defined procedures and controls and by Chaotic teams that do not understand their assignments nor how to operate effectively. Management of the product development process is not applied consistently in projects, and modern tools and technology are not used consistently, if at all.
2. Repeatable	Standard methods and practices are used for monitoring progress, requirements changes, cost estimation, etc. The process is repeatable. False teams may exist at this stage.
3. Characterized	The process is well characterized and reasonably well understood. A series of organizational and process improvements have been implemented. There is a group responsible for implementing and monitoring the product development process. Conflict resolution is the principal focus of product development teams.
4. Managed	The process is not only characterized and understood but is also quantified, measured, and reasonably well controlled. Tools to control and manage the process are used. The uncertainty concerning the process outcome is reduced. True teams are used in the product development process.
5. Optimizing	A high degree of control is used over the process and there is a major focus on significantly and continually improving operations by using process metrics and lessons learned.

Table 1 - CE Process Maturity Stages

1 Notice the choice of words for the names of the stages. The names suggest that an organization can attain any of the first four stages and move on to the next stage. On the other hand, an organization cannot proceed beyond the fifth stage. The name of this stage "Optimizing" has a connotation of continuous improvement.

In practice, the five stages are differentiated based on the critical elements of CE described in Table 2. A questionnaire-based mechanism for placing an organization into one of the maturity stages is utilized. This mechanism is similar to the one proposed in [3,6].

Customer focus	• Understanding of the customer requirements and expectations. • Methodology to capture and deploy customer requirements. • Constant attention to customer requirements satisfaction. • Rapid assessment and accommodation of new priorities.
Process focus	• Understanding of the value chain and linkages with the customer and supplier value chains. • Modeling of process workflows. • Documentation of process capabilities and metrics. • Identification and control of critical process events and parameters. • Relentless pursuit of process improvement (re-engineering focus).
Strategies for team formation and development	• Representation of all relevant (internal and external) life-cycle perspectives in the product development process from the early stages. • Rationale for team assignment. • Team training (social and analytical skills). • Team launch procedures. • Team performance measures.
Accommodation of teams within the organization	• Physical or virtual collocation. • Career paths for members of cross-functional teams. • Team recognition and incentives. • Management directive describing team responsibilities, authority, and accountability. • Operation of teams as strategic business units in the value chain. • Removal of organizational barriers to effective teamwork.
Management systems	• Risk (uncertainty) management. • Integrated master planning and scheduling. • Value-based resource allocation. • Cost/schedule control systems. • Technical performance monitoring. • Program-based budget authority.
Mechanisms for rapid product assurance	• Adoption of product standards. • Adoption of robust design principles. • Application of computer aided design and simulation tools. • Use of rapid prototyping tools. • Adoption of off-line and on-line quality control methods.
Agility	• Ability to respond gracefully to change. • Effective use of technology. • Corporate memory.
Leadership of senior management	• Leadership role model. • Commitment to the resolution of issues at the lowest level. • Commitment to support CE throughout the transformation cycle. • Relentless pursuit of improvement. • Resource allocation.

2.2 Technology Assessment

Similar to the process maturity stages, stages concerning the introduction and utilization of advanced tools and technology may be identified. Two stages, Inefficient and Basic, are defined in [3] in the context of software development. This classification is a bit coarse for our purpose; therefore, three stages (Basic, Intermediate, and Advanced) for different technology areas are considered, see Table 3. The number of stages is restricted to three because, one, since the technology is rapidly advancing a finer classification can cause the assessments to change frequently, two, since a number of factors are involved fine distinctions into a large number of categories is hard to make, and three, an odd number of stages is helpful in scaling the responses.

1. Basic	Technology for increasing individual productivity. Underutilization and inefficient use of technology. Minimal use of computers and computer-based tools.
2. Intermediate	Moderate use of proven technologies for increasing group effectiveness.
3. Advanced	Utilization of state-of-the-art technology which is kept current. Conscious assimilation of technology into the work culture. Technology mediated group work.

Table 3 - CE Technology Maturity Stages

The technology under consideration for CE is essentially computer-based, and the tools are divided into two categories: Application Tools and Generic Services. Application tools are application-specific computer-based tools that assist in product definition based on life-cycle considerations. Generic services, that support virtual tiger teams, fall under the following categories:

- Communication services, e.g., networking, multimedia communication;
- Coordination services, e.g., on-line project monitoring, constraint management;
- Information Sharing services, e.g., shared product models, electronic design notebooks; and
- Integration services, e.g., data and tool wrappers.

Tools developed to implement each of these services often rely upon the technology in more than one area. For example, a tool for team coordination will utilize the communication services as well as the availability of shared data, an information sharing service.

A description of these three stages for application tools and each of the generic services is presented in Appendix A. There may be an overlap in the specification of the stages for the technologies, e.g., the specification of stages for coordination services depends upon the categorization of the communication services. The definition of the stages is not fixed; what is an Advanced stage today may be considered an Intermediate stage in the future.

2.3 Process-Technology Interaction

The position of a product or project group in an organization with respect to process practices and the utilization of tools and technology is captured in Figure 1. The result of a sample assessment is shown by dots (which have been connected). The process

assessment is conducted based on the critical elements of CE and the technology assessment is ccnducted in the application tools and each of the generic service categories.

The information captured in Figure 1 gives an idea of the current status of the product development processes and can provide pointers to the improvement path to be taken. In particular, one can determine what strategic (process-oriented) and tactical (tool-oriented) decisions need to be made to implement CE practices. The decisions should aim to advance the technology employed by the organization along the stages and to ensure a balance in the advancc. The balance is crucial because, for example, one cannot have good coordination without effective communication, and the effective usc of advanced application tools requires sound communication and information sharing services.

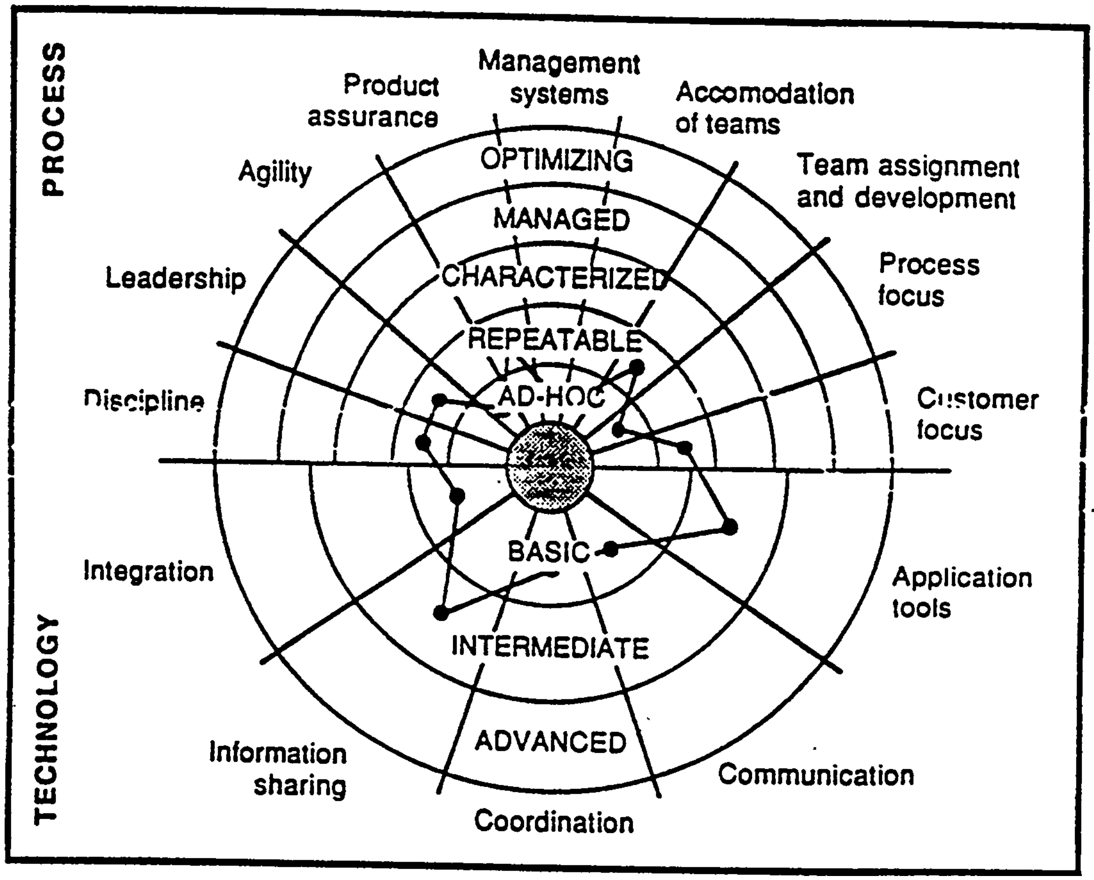
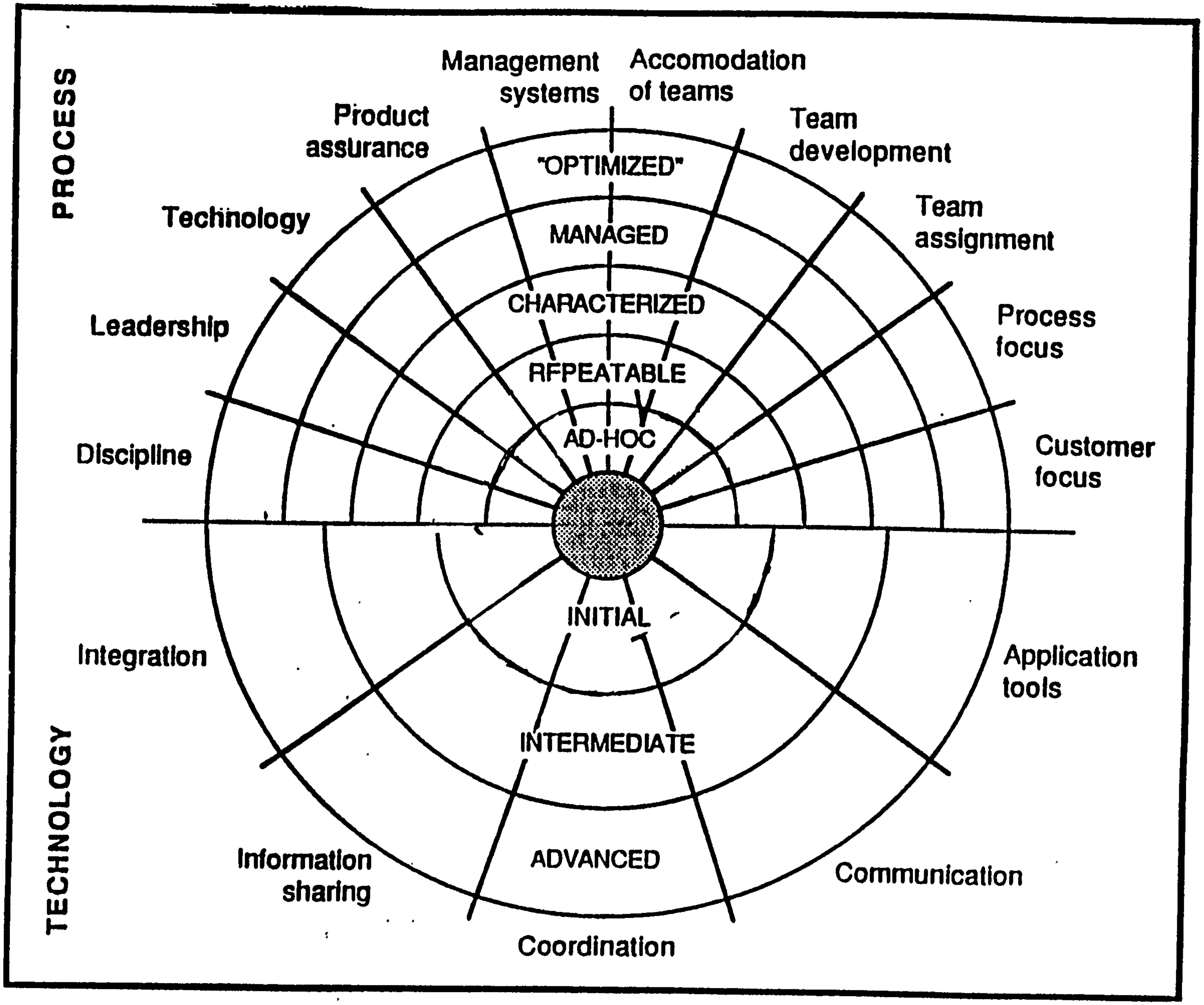


Figure 1 - CE Assessment Diagram


PROCESS
Management systems
Accomodation of teams
Product assurance
Team development
Technology
Team assignment
Leadership
Process focus
Discipline
Customer focus
"OPTIMIZED"
MANAGED
CHARACTERIZED
RFPEATABLE
AD-HOC
INITIAL
INTERMEDIATE
ADVANCED
Integration
Application tools
Information sharing
Communication
Coordination
TECHNOLOGY

CE IMPLEMENTATION

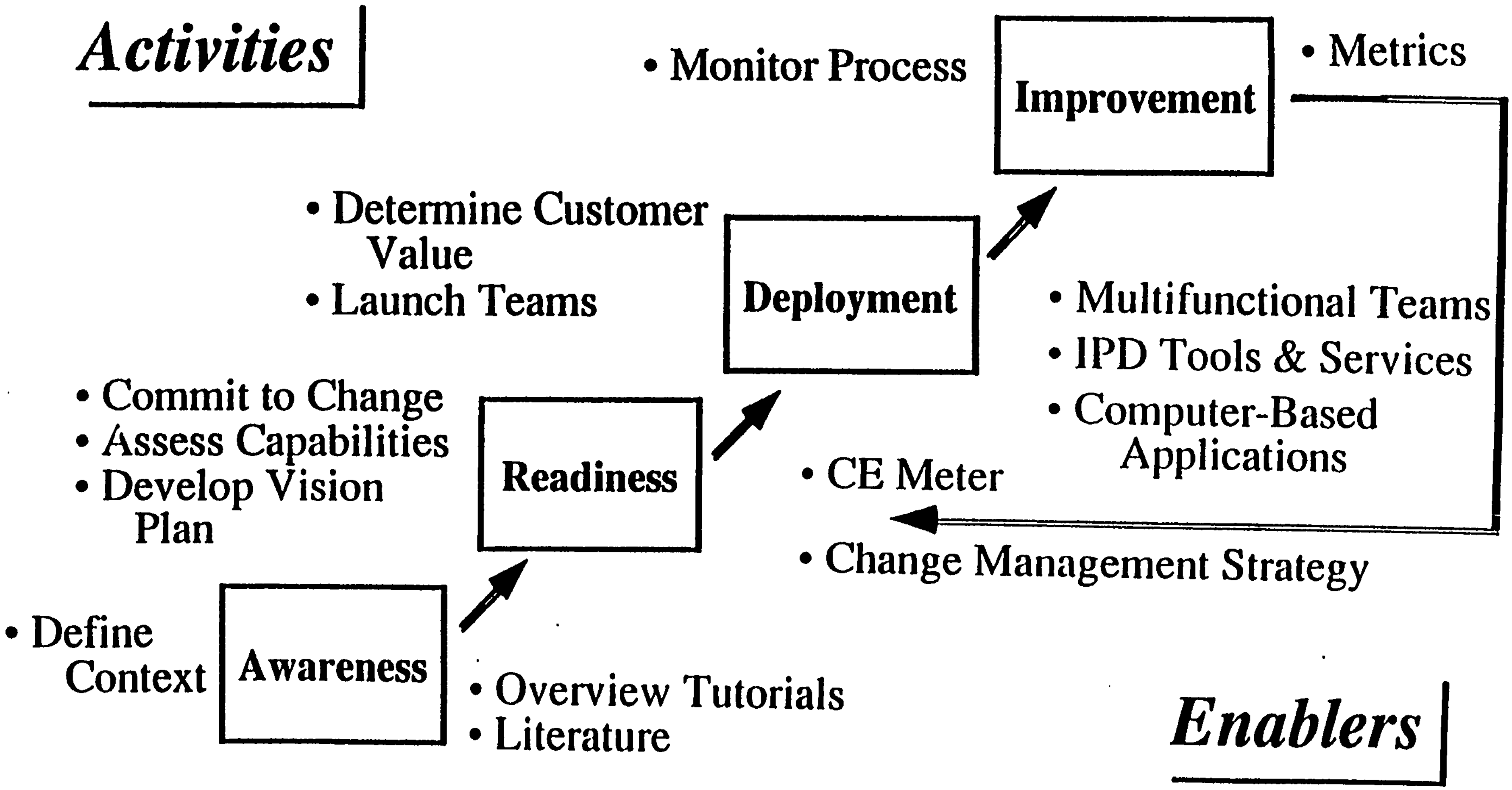
HAVING DETERMINED HOW READY YOU ARE, THE ASSESSMENT CAN BE USED TO DECIDE WHAT STRATEGIC (PROCESS ORIENTED) AND TACTICAL (TOOL ORIENTED) STEPS MUST BE TAKEN

THE COMPANY'S EXISTING CULTURE, TECHNOLOGY, ORGANIZATION AND OPERATIONAL METHODS WILL ALL NEED TO BE REALIGNED TO SUPPORT THE NEW PROCESS

YOUR BEST PEOPLE TO GIVE THE BEST POSSIBLE
CHANCE FOR SUCCESS

UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE

Concurrent Engineering Implementation



CE BARRIERS TO IMPLEMENTATION

AS WITH ANY ATTEMPT TO IMPLEMENT CHANGE, IT IS HELPFUL TO KNOW WHAT ARE THE BARRIERS

OTHER CE IMPLEMENTERS HAVE EXPERIENCED THE FOLLOWING BARRIERS:

- LACK OF TOP MANAGEMENT COMMITMENT AND SUPPORT
- LACK OF CE KNOWLEDGE AND EXPERIENCE
- NO CROSS-FUNCTIONAL TEAMING EXPERIENCE
- PERCEIVED THREAT TO FUNCTIONAL MANAGER POSITION AND AUTHORITY
- MANAGEMENT WILL NOT DELEGATE
- TOO MUCH INTERNAL POLITICS AND INTERDEPARTMENT CONFLICT
- LACK OF TRUST
- ASSIGNING BLAME MORE IMPORTANT THAN RESOLVING PROBLEMS
- UNSUITABLE ORGANIZATION CULTURE
- UNABLE TO GET DOWN STREAM DEPARTMENTS INVOLVED UP FRONT

IMPLEMENTATION LESSONS LEARNED

LESSONS FOR SUCCESS

- THE REASON OR NEED FOR THE CHANGE TO CE SHOULD BE SHARED WITH ALL PARTICIPANTS.
- ASSURE THAT ALL PARTICIPANTS HAVE A COMMON UNDERSTANDING AND DEFINITION OF CE.
- GAIN PERSONAL EXPERIENCE BY PERFORMING PILOT PROJECTS.
- CAREFULLY SELECT PILOT PROJECT. IT SHOULD BE MEANINGFUL, VISIBLE AND ACHIEVABLE IN A SHORT TIME.
- BUILD ON PILOT PROJECT SUCCESS BY FORMING MORE PILOT PROJECT TEAMS AFTER EACH SUCCESSFUL PILOT PROJECT COMPLETION.
- USE ENTHUSIASTIC SUCCESSFUL TEAM MEMBERS TO ASSIST FALTERING TEAMS AND CONVERT DOUBTERS.
- SELECT BEST PERSONNEL FOR PILOT PROJECT TEAM(S).

LESSONS FOR SUCCESS (Continued)

- INSTITUTIONALIZE SUCCESSFUL CE IMPLEMENTATION. ENSURE CE BECOMES PART OF THE SHIPYARD CULTURE.
- SELL THE APPROACH FROM THE TOP DOWN - THE VISION HAS TO COME FROM THE TOP. HOWEVER, IMPLEMENTATION MUST BE FROM BOTH THE TOP DOWN AND THE BOTTOM UP. COMMITMENT MUST BE SHARED FROM THE TOP TO THE BOTTOM.
- USE ACE STEERING COMMITTEE FOR TOP/MIDDLE MANAGERS WHO CAN BECOME CE CHAMPIONS.
- USE A MEMBER OF THE STEERING COMMITTEE AS THE SPONSOR FOR PRODUCT TEAMS.
- PRODUCTION ROLE MUST BE CLEARLY DEFINED UP FRONT TO PREVENT PRODUCTION FROM SIMPLY EXTENDING THEIR CUSTOMARY "DESIGN REVIEW ROLE.
- TRAIN CROSS-FUNCTIONAL TEAMS NOT FUNCTIONAL GROUPS.
- TRAINING OF TEAMS IN TEAM SKILLS MUST BE COMPLETED BEFORE TEAM STARTS ON THE ACTUAL PRODUCT DESIGN PROCESS.

LESSONS FOR SUCCESS (Continued)

- THE ORGANIZATION STRUCTURE MUST BE CHANGED TO FIT AND SUPPORT THE CE PROCES
- LET THE NEW CE TEAM(S) VISIT ESTABLISHED TEAMS TO SEE THE RESULTS AND HOW OTHERS APPLY CE.
- FUNCTIONAL MANAGERS MUST BE TRAINED FO THEIR NEW ROLE.
- FUNCTIONAL MANAGERS SHOULD BE INVOLVED DEFINING THEIR NEW ROLE.
- REWARD SYSTEM MUST ENCOURAGE TEAM SUCCESS AND NOT INDIVIDUAL PERFORMANCE.
- USE FREQUENT TOP MANAGEMENT REVIEWS TO KEEP THEM INVOLVED IN PROCESS AND SHARE OWNERSHIP OF DECISIONS.
- BOTH CUSTOMER AND MAJOR SUPPLIERS MUST INVOLVED AS FULL TEAM MEMBERS.
- DEVELOP AND GET MANAGEMENT AND TEAM AGREEMENT ON METRICS THAT MEASURE PRODUCT AND PROCESS QUALITY AND PERFORMANCE BEFORE THE PRODUCT DESIGN COMMENCES.

LESSONS FOR SUCCESS (Continued)

- **TEAM MUST DEVELOP ITS OPERATING PROCESS BEFORE STARTING PRODUCT DESIGN PROCESS.**
- **TEAM GOALS AND OPERATING BOUNDARIES MUST BE CLEAR.**
- **TEAMS MUST CONTINUALLY MEASURE HOW THEY ARE PERFORMING AS A TEAM.**
- **USE A COMPREHENSIVE CE IMPLEMENTATION PLAN FOR EACH PILOT PROJECT UNTIL CE IS INSTITUTIONALIZED IN THE SHIPYARD.**
- **ESTABLISH SHIPYARD WIDE GUIDING PRINCIPLES AND VALUES.**

THINGS TO AVOID

- PARTIAL IMPLEMENTATION OF CE. MUST SELEC A SLICE THROUGH THE COMPLETE ORGANIZATION INVOLVING AS MANY OF THE DEPARTMENTS AS POSSIBLE FOR THE TEAM RATHER THAN JUST A FEW “IMPORTANT” DEPARTMENTS.
- CHANGING TOOLS AND INFORMATION WITHOUT REQUIRED PROCESS CHANGES.
- MANAGEMENT UNDERSTATING EXTENT OF CHANGE REQUIRED TO SUCCESSFULLY IMPLEMENT CE.
- FAILURE TO REMOVE/REPLACE PROBLEM MEMBERS IN CE TEAMS.
- MANAGEMENT SENDING MIXED SIGNALS ABOUT CE - SAYING ONE THING BUT DOING ANOTHER
- MOCKERY OF DELEGATED AUTHORITY BY MANAGEMENT OVER-RIDING TEAM DECISIONS.
- FUNCTIONAL MANAGERS CONSTRAINING CROSS-FUNCTIONAL TEAM MEMBERS BY INSISTING TH BE CONSULTED BEFORE THEY MAKE DECISIONS.
- IGNORING THE CUSTOMERS.
- IGNORING THE SUPPLIERS.

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IMPLEMENTATION FRAMEWORK

OTHER IMPLEMENTERS OF CE HAVE ESTABLISHED PROCESSES THAT ENCOMPASS MANY OF THE LESSONS LEARNED LISTED ABOVE. COMBINING THESE PROCESSES PROVIDES A FRAMEWORK FOR A CE IMPLEMENTATION PLAN.

1. **TRAIN TOP MANAGEMENT - CE AND TEAM DYNAMICS/SKILLS.**
2. **ESTABLISH CE STEERING COMMITTEE.**
3. **SELECT POTENTIAL TEAM MEMBERS.**
4. **TRAIN POTENTIAL TEAM MEMBERS AND FUNCTIONAL MANAGERS - CE AND TEAM DYNAMICS/SKILLS.**
5. **PERFORM CE READINESS SELF-ASSESSMENT.**
6. **DETERMINE REQUIRED CHANGE/IMPROVEMENTS TO BE READY TO IMPLEMENT CE.**
7. **GO - NO GO DECIS1ON.**
8. **INITIATE REQUIRED ORGANIZATIONAL AND CULTURAL CHANGES.**
9. **ASSIGN A STEERING COMMITTEE MEMBER AS PILOT PROJECT SPONSOR.**

IMPLEMENTATION FRAMEWORK
(Continued)

10. SELECT PILOT PROJECT.

11. CREATE CROSS-FUNCTIONAL TEAM.

12. TEAM DESIGNS TEAM OPERATING SYSTEM.

13. CURRENT PRODUCT PROCESS CAPTURED AND ANALYZED BY TEAM.

14. TEAM DEVELOPS TEAM METRICS.

15. TEAM DECIDES CE TOOLS TO BE USED.

16. TEAM DEVELOPS PILOT PROJECT PLAN.

17. TEAM PRESENTS GOALS, METRICS AND PLAN TO SPONSOR AND THEN STEERING COMMITTEE.

18. PERFORM REGULAR SELF-ASSESSMENTS OF TEAM PERFORMANCE AGAINST SELECTED GOALS, METRICS AND THE PLAN.

19. APPLY “LESSONS LEARNED” TO OTHER PROJECTS TO CONTINUALLY IMPROVE THE CE PROCESS.

METRICS

A METRIC CONSISTS OF TWO OR MORE MEASUREMENTS OR SINGLE DATA POINTS. FOR EXAMPLE, PRODUCT DESIGN MANHOURS ISA MEASUREMENT, BUT THE COMPARISON OF CURRENT PRODUCT DESIGN MANHOURS TO PREVIOUS PRODUCT DESIGN MANHOURS IS A METRIC.

THE LACK OF COMMONLY ACCEPTED CE PROCESS, LACK OF MEASUREMENT STANDARDS OR EVEN NORMS AND THE MULTI-FACETED INTERFACE COMPLEXITY OF CE, ADD TO THE ABOVE PROBLEMS TO MAKE THE DEVELOPMENT AND USE OF CE METRICS VERY DIFFICULT.

ONCE THE METRICS ARE DEVELOPED IT IS STILL NECESSARY TO DECIDE HOW THE INFORMATION WILL BE COLLECTED, THE METRICS COMPUTED AND THE RESULTS USED. ALSO, FOR SPECIAL METRICS DEVELOPED BY A SHIPYARD, THE QUESTION OF VALIDATION MUST BE ANSWERED.

NOT WITHSTANDING THESE PROBLEMS WITH METRICS, IT IS BETTER TO HAVE INVALIDATED METRICS THAN NO METRICS. AS THE METRICS ARE APPLIED OVER TIME THEY CAN BE REFINED.

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CE METRICS

MUST ADDRESS THE BASIC TENANTS OF CE

- INTEGRATED PRODUCT AND PROCESS DESIGN
- CONCURRENT PRODUCT AND PROCESS DESIGN
- MEET CUSTOMER REQUIREMENTS
- USE CROSS FUNCTIONAL TEAMS
- CONSENSUS DECISION MAKING

METRICS SHOULD BE:

- **SIMPLE**
- **EASILY OBTAINED**
- **OBJECTIVE - DIFFERENT PEOPLE ASSIGN SAME VALUE TO THE METRIC**
- **VALID - MEASURE WHAT IS INTENDED**
- **ROBUST - INSENSITIVE TO SMALL CHANGES IN PRODUCT OR PROCESS**
- **PROVIDE A BASIS FOR PREDICTIVE PROCESS MODELIING**

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USEFUL MEASUREMENTS ARE:

- CUSTOMER SATISFACTION,
- PRODUCT COST,
- TIME TO MARKET,
- PRODUCT DESIGN MANHOURS,
- PRODUCT DESIGN TIME,
- PROCESS DESIGN MANHOURS,
- PROCESS DESIGN TIMES,
- NUMBER OF ENGINEERING CHANGES,
- DURATION OF TIME CHANGES,
- MANUFACTURING MANHOURS,
- MANUFACTURING TIME,
- NUMBER OF QUALITY DEFECTS,
- PRODUCT DESIGN MANHOURS FOR REWORK,
- PROCESS DESIGN MANHOURS FOR REWORK,
- MANUFACTURING MANHOURS FOR REWORK,
- FUNCTIONAL INTEGRATION - NUMBER OF FUNCTIONS INVOLVED IN PRODUCT DESIGN
- TIME TO REACH TEAM CONSENSUS,
- NUMBER OF MEETINGS TO REACH CONSENSUS,
- TEAM COMMITMENT, AND
- NUMBER OF NEW PRODUCTS LAUNCH PER YEAR.

TYPICAL METRICS

MEASUREMENTS CAN ALL BECOME METRICS BY COMPARING CURRENT VALUE WITH PAST VALUES.

OTHER CE PROCESS METRICS ARE;

- **CONCURRENCY INDEX,**
- **COMMON UNDERSTANDING RATIO,**
- **TEAM DISPERSION INDEX,**
- **REQUIREMENTS STABILITY,**
- **PROCESS RESPONSE,**
- **MANAGEMENT INVOLVEMENT,**
- **PLAN COMPLIANCE,**
- **COMMUNICATION INDEX,**
- **CONFLICT INDEX, AND**
- **INFORMATION SHARING INDEX.**

A SUCCESSFUL CONCURRENT ENGINEERING DESIGN PROCESS

INCLUDES THE FOLLOWING:

- AN AUTOMATED LINK AMONG DESIGN ENGINEERING, MANUFACTURING, AND THE LOGISTICS PROCESSES AND FUNCTIONS IN ORDER TO FACILITATE THE TRANSFER OF TECHNICAL INFORMATION.
- DATABASES OF PRODUCT DEFINITION, CONFIGURATION, AND LOGISTICS DATA THAT ARE SHARED AMONG THE VARIOUS DISCIPLINES.
- SOFTWARE TOOLS THAT SUPPORT THE INTEGRATION OF COMPUTER-AIDED ENGINEERING ANALYSIS TOOLS WITH THE COMPUTER-AIDED DESIGN FUNCTION. THIS IMPLIES THE EXISTENCE OF COMPONENT PART LIBRARIES, MATERIALS CHARACTERISTICS DATABASES, AND COMPONENT PERFORMANCE CHARACTERISTICS DATABASES.
- THE CAPABILITY TO DISTINGUISH BETWEEN VARIOUS CATEGORIES OF DESIGN DATA (WORKING, SUBMITTED, APPROVED) AND TO PROVIDE DATA TRACEABILITY THROUGH-OUT VARIOUS DESIGN ITERATIONS.
- THE ABILITY TO RESTRICT ACCESS TO DESIGN DATA BY UNAUTHORIZED PERSONNEL, WHILE PROVIDING REMOTE ACCESS TO DATA BY THE CUSTOMER
- THE CAPABILITY TO DEVELOP A COMPREHENSIVE PRODUCT MODEL OF THE SHIP COMPONENT SYSTEM
- THE CAPABILITY TO MANAGE AND RAPIDLY COMMUNICATE DESIGN AND CONFIGURATION CHANGES.

ENABLING TOOLS

ENABLING TOOLS ARE DIVIDED INTO TWO CATEGORIES, NAMELY; APPLICATION TOOLS AND GENERIC SERVICES.

APPLICATION TOOLS ARE APPLICATION SPECIFIC COMPUTER BASED TOOLS THAT ASSIST IN PRODUCT DEFINITION.

GENERIC SERVICES SUPPORT TEAMS IN THE FOLLOWING CATEGORIES:

- COMMUNICATION SERVICES - NETWORKING, MULTI-MEDIA COMMUNICATION.
- COORDINATION SERVICES - ON-LINE PROJECT MONITORING, CONSTRAINT MANAGEMENT.
- INFORMATION SHARING SERVICES - SHARED PRODUCT MODEL, CORPORATE MEMORY.
- INTEGRATION SERVICES - DATA AND TOOL WRAPPERS.

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COMPUTER SUPPORT

COMPUTER SUPPORT IS ESSENTIAL FOR MOST CE APPLICATIONS AS CE INCREASES THE NUMBER OF ACTIVITIES THROUGH GREATER DECOMPOSITION OF THE WORK AND INCREASES THE COMPLEXITY OF THE PARALLEL PERFORMANCE OF THE WORK INTERFACES.

COMPUTER SUPPORT FOR CE HAS FIVE BASIC ELEMENTS, NAMELY;

- INTEGRATING TOOLS AND SERVICES
- CAPTURING CORPORATE HISTORY
- SHARING INFORMATION
- COORDINATION OF THE TEAM
- COLLOCATING PEOPLE AND PROGRAMS

THE OBJECTIVE OF ALL THESE ELEMENTS IS TO PROVIDE A DECISION SUPPORT SYSTEM TO HELP TEAMS MAKE AND RECORD DECISIONS.

COMPUTER SUPPORT

[Continued)

THE LARGE NUMBER OF CAD/CAM TOOLS USED IN THE PRODUCT DESIGN PROCESS ARE NOT CURRENTLY INTEGRATED.

DIFFERENT DEPARTMENTS IN THE SAME COMPANY USE DIFFERENT SYSTEMS, DIFFERENT TERMINOLOGY AND DIFFERENT DATABASES.

THEREFORE, AN ESSENTIAL NEED FOR COMPUTERS IN THE CE PROCESS IS TO FIND A WAY FOR THE INDIVIDUAL TOOLS TO INTERACT AND COOPERATE.

THE INTEGRATED CE COMPUTER ENVIRONMENT WILL CONSIST OF THE VARIOUS CAD/CAM TOOLS AND AN ENVELOPING FRAMEWORK

THE FRAMEWORK GUIDES DESIGNERS THROUGH THE COMPLETE PRODUCT DESIGN PROCESS SO THAT THEY CAN EFFECTIVELY ACHIEVE A DESIGN WITH THE HIGHEST QUALITY IN THE SHORTEST TIME AND LOWEST COST.

CE ENABLING SOFTWARE TAXONOMY

Information Management	Computer Mediated Communication	Coordination	Tool Integration	Tools	Corporate Memory
- Data Modeling - Version /Configuration Management - Legacy Data Sharing - Standards - EDI	- E-Mail - Desktop Conferencing - Shared Applications (WYSIWIS) - Group Decision Support	- Shared Decision Models - Shared Task Structure -Requirements Management - Progress Assessment - Consensus Building - Team Structuring - Calendering and Scheduling	- Standards - Translators / Wrappers - User Interfaces	- CAx - Design for x - Simulation - Spreadsheets - Document Production Systems	- Annotation - Argumentation - E-mail Database - Meeting Minutes - Indexing and Retrieval - Results Capture

CERC

CE COST BENEFIT

ACTUAL COST BENEFITS OF CE ARE NOT WIDELY SHARED

ONE PARTICULAR STUDY SHOWED BENEFIT/ COST RATIOS RANGING FROM 2.8 TO 8.6

EXPERIENCE HAS SHOWN THAT COST BENEFIT GROWS OVER PRODUCT LIFE CYCLE

CE IN SHIPBUILDING

NSRP SP-8 CE STUDY

MID-TERM SEALIFT PROGRAM
- ENGINE ROOM ARRANGEMENT MODELLING

NAVY ACQUISITION IPPD STUDY

LPD 17 PROGRAM

DoDD DIRECTIVE 5000.1 & INSTRUCTION 5000.2

CE OVERVIEW SUMMARY

CE IS A PROVEN APPROACH TO REDUCE COST AND DESIGN AND BUILD CYCLE

CE CAN BE USED BY U.S. SHIPBUILDERS TO ASSIST THEM ACHIEVE INTERNATIONAL COMPETITIVENESS IN COMMERCIAL SHIPBUILDING

HOWEVER, OTHER COUNTRIES ARE BEGINNING TO USE IT AS WELL AND SOME SAY THEY ARE UTILIZING IT BETTER BECAUSE OF THEIR LESS INDIVIDUAL COMPETITIVE AND ADVERSARIAL CULTURES THAN IS COMMON IN THE U.S.

IT REQUIRES SIGNIFICANT CHANGES THAT U.S. SHIPYARDS MAY NOT BE WILLING TO UNDERTAKE. SHIPYARDS ARE WELL KNOWN FOR THEIR TRADITIONALISM AND THIS WILL BE A MAJOR BARRIER TO OVERCOME.

IT IS HOPED THAT THIS WORKSHOP CAN PLAY A PART IN BRINGING THIS ABOUT.

NATIONAL SHIPBUILDING RESEARCH PROGRAM

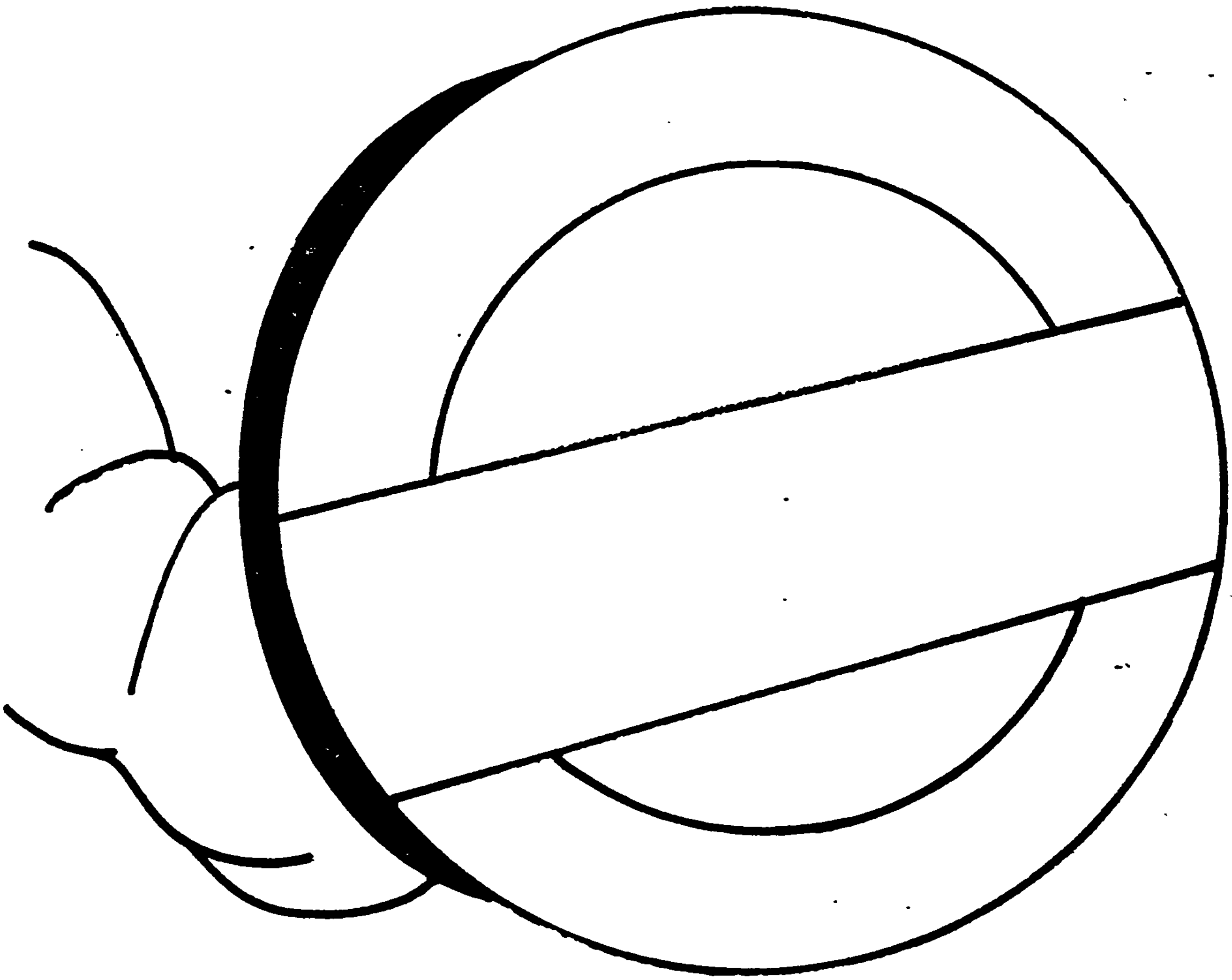
TEAMS

IMPLEMENTING ADVANCED TECHNOLOGY

2.75

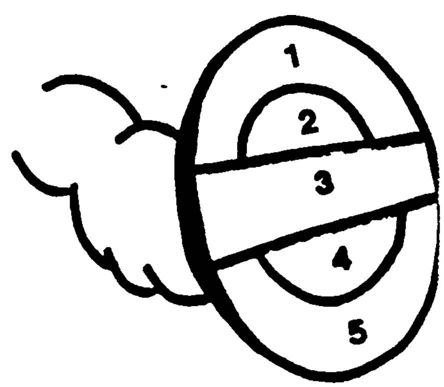
ALL FOR ONE AND ONE FOR ALL

SHIELD



Key for shield design:

area 1 = Write something you excel at doing.
area 2 = Draw a picture representing
a one-time peak performance.
area 3 = Write your credo or key value you live by. .
area 4 = Draw a symbol of your favorite leisure activity.
area 5 = Describe in words one of your hidden qualities.



"ONE FROM COLUMN A AND ONE FROM COLUMN

BELIEFS QUIZ

Instructions: Place a check mark in appropriate columns according to-your beliefs. Add notes to aid in team discussion later.

	A team can change	B team must live with	C team must influence outsiders to act	notes
1 priorities				
2 corporate climate				
3 roles within the team				
4 relationships between team members				
5 competencies of team members				
6 operations				
7 facilities				
8 systems				
9 suppliers/vendors				
10 customers				

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TEAMS AND TEAMWORK

TEAMS AND TEAMWORK NOT THE SAME

TEAMWORK DOES NOT REQUIRE TEAMS AND OCCURS WHEN INDIVIDUALS IN A GROUP BEHAVE IN A COOPERATIVE MANNER WITH OTHER INDIVIDUALS FOR THE BENEFIT OF THE GROUP AS A WHOLE

A TEAM IS A GROUP THAT VISIBLY SHARES A COMMON PURPOSE, AND RECOGNIZES IT NEEDS THE EFFORT OF EBERYONE OF ITS MEMBERS TO ACHIEVE THE PURPOSE.

COMPARISON OF TEAM TYPES

TEAM PARAMETER	CE TEAM	TASK TEAM	TIGER TEAM
OBJECTIVE	Product delivery	Task Completion	Problem solving and proposals
ORIENTATION	Design for life cycles (proactive)	Ensure task requirements met (reactive)	Solve the problem (reactive)
RESPONSIBILITY	Deliver product to realistic specifications at low cost in minimum time	Complete task within budget and on time	Recommend and implement solutions
AUTHORITY	At team level	Functional managers and designers	Team leader
LEADERSHIP FUNCTION	Facilitate, coordinate, spokesperson	Coordinate	Coordinate, direct
DURATION	Product development from proposal to disposal	Short term for each task and then disband	Short term, for time to solve problem
STRUCTURE	Cross functional teams addressing product processes	Single function teams working on single function task	Cross functional teams solving a specific problem

Characteristics of Effective and Ineffective Teams

	Effective	Ineffective
Information		
	Flows freely up, down, sideways	Flows mainly down, weak horizontally
	Full sharing	Hoarded, withheld
	Open and honest	Used to build power
		Incomplete, mixed messages
***People* relationships**		
	Trusting	Suspicious and partisan
	Respectful	Pragmatic, based on need or liking
	Collaborative	Competitive
	Supportive	Withholding
Conflict		
	Regarded as natural, even helpful	Frowned on and avoided
	On issues, not persons	Destructive
		Involves personal traits and motives
Atmosphere		
	Open	Compartmentalized
	Nonthreatening	Intimidating
	Noncompetitive	Guarded
	Participative	Fragmented, closed groups
Decisions		
	By consensus	By majority vote or forcing
	Efficient use of resources	Emphasis on power
	Full commitment	Confusion and dissonance
Creativity		
	More options	Controlled by power subgroups
	Solution-oriented	Emphasis on activity and inputs
Power base		
	Shared by all	Hoarded
	On competence	On politicking, alliances
	Contribution to team	Pragmatic sharing
		Contribution to power source
Motivation		
	Commitment to goals set by team	Going along with imposed goals
	Belonging needs satisfied	Coercion and pressure
	More chance for achievement through group	Personal goals ignored individual achievement valued without concern for the group
Rewards		
	Based on contribution to group	Basis for rewards unclear
	Peer recognition	Based on subjective, often arbitrary appraisals

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Team Selection Process

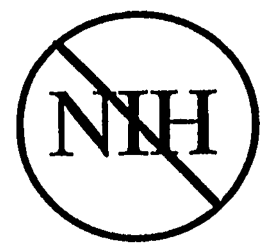
Program Management (Proposal) Team
- Leadership abilities
- Customer awareness

Systems Engineering Team
- Life-cycle expertise

Product/Process Teams
- Technical expertise
- Willingness

Team Member Qualities

- Respected for technical expertise and experience
- Unselfish, open-minded contributor and evaluator



- Mentors and supports others
- Handles conflict without getting “personal”
- Self-disciplined (on time, on budget)

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MASTERING MASTERY

PRINCIPLES OF MASTERY

1. All team members are capable of excellence.
2. The instructional process can be changed to improve learning.
3. Individual differences have an impact especially on learning time and instructional quality.
4. Learning to learn is a key to higher levels of competency.
5. Assessment of learning must be continuous and fed back into the instructional development process.
6. Individuals need opportunities to demonstrate success.
7. Team training must be designed for individuals according to learning objectives for each individual.
8. Jobs must be systematically analyzed. Measures indicating competent performance must be established for critical tasks within jobs.
9. Learners must know what the performance standards are and instructors must design instruction to lead individual learners to achieving those standards.

HOW TO DEVELOP A SKILLS-BASED LEARNING PlAN -

1. Analyze a job according to “people-data-things” analysis.
2. Assign a weight (easy, medium, hard) to each task within the job.
3. Set a quantitative criterion of skill performance for each task.
4. Design an evaluation instrument for each person that measures achievement for each task according to the established criteria.
5. Develop a “Need to Know” matrix for the team incorporating all of the results of the above analyses. Use this as a basis for developing individual team members through a tailor-made skills-based learning program.

Team Ownership

- **Understanding -** of assignment
- **Responsibility -** to carry out assignment
- **Authority -** to make decisions and commit resources
- **Accountability -** for customer value
- Skills - to handle empowerment and responsibility
- **Incentives -** for knowledge and team performance

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Team Membership Commitment

Core

- Attends all reviews
- Participates in all team decisions
- Source for team's "corporate knowledge"

Resource

- Attends reviews as requested
- Provides information supporting particular team decisions

# of Team Membership

isciplines / Functions (Examples)

Subcontracts	Program Controls	Subcontractor	Supportability	Reliability	Software	Integrated Logistics Support	Safety	Test	Configuration Mgmt	Customer	Other (e.g., Analysis)
	△	△	○	△		△	△	○		△	○
	△		○		△	△		○			
	△		○			△		○			○
○	△		△	△		△	△	△	○	△	○

Team Roles

Leader

- Plans, coordinates, follows-through
- Directs, observes, coaches, supports
- Monitors performance, leads improvements

Scribe

- Records team's corporate history
- Upholds team's communication plan

Rat-Hole Protector

- Signals deviation from topic

MANAGING CONFLICT AS THE TEAM LEADER

There will be times when a conflict between two members of the team prevents each member from being fully effective-and keeps the team from moving forward. Try to resolve the confiict quickly by asking each party to the dispute to respond to the following statements in private. Ask them to use only positive statements—nothing “finger pointing” such as “He should stop doing. . . ." Then bring the two together and help them look for ways to boil their responses down to objectives that both of them can agree with. Finally, show what has to be done to satisfy those objectives, who does what, and when.

- I believe that he (she) should:

____

____

____

- He (she) believes that I should:

____

____

____

- I believe that I should:

____

____

____

- He (she) believes that he (she) should:

____

____

____

Group Decision Making

- Decision by Authority
- Decision by Minority
- Decision by Majority Vote
- Decision by consensus
- Decision by Unanimous Agreement

Team Norms

- **Be Open**
- **Be Honest**
- **Be Focused**
- **Think Team**

Cooperate	Respect
Trust	Communicate
Share	Participate

Consensus is Precious

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Difficult Behavior

- The Clam
- The Distractor
- The Rambler
- The Hog
- The Bully
- The Clown

Team Staffing Practices

Team Selection Options

- Assignment by program organization
- Recommendation/refusal by team

Team Continuation

- Team discharges member
- Team recommends discharge to higher authority

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Team Communications Plan

- Needs
- Flow Model
- Meetings
- Off-Line Discussions
- Communications Technology
- Archive/Configuration/Retrieval/Authorization

Team's Strategic Plan

Vision - what we want to become or be known for

Mission - what we want to do

Objectives - where we will win

Goals - how we want to be measured

Strategies - how we will win

Initiatives - tasks we will perform

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Integrated with Program/Product Plan

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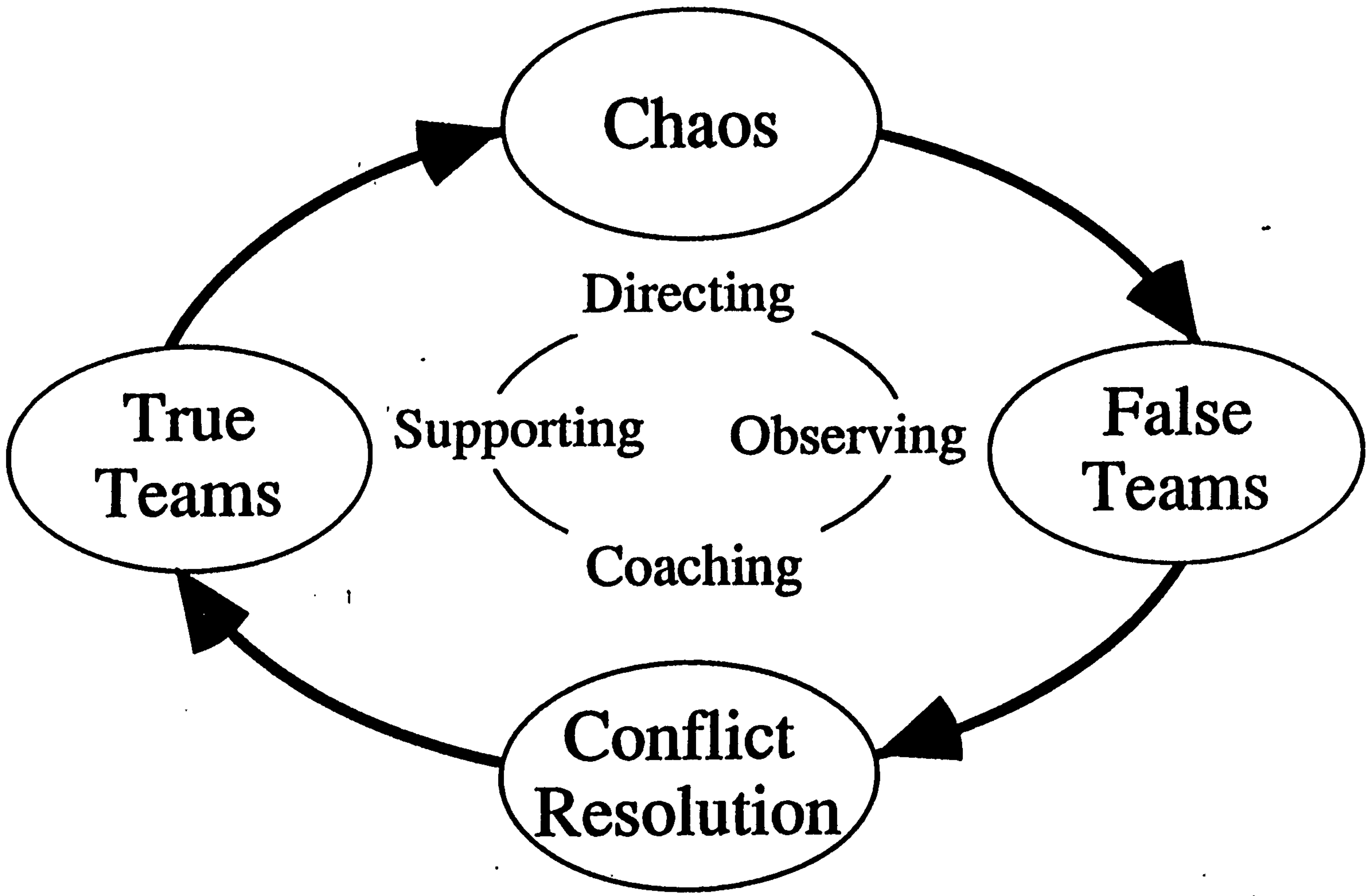
Team Launch Strategies

- Launch real teams on real projects
- Practice team culture and management while doing real work as a team
- Employ IPD tools to develop real program plans
- Produce lessons learned and next steps for "Monday morning"

Team Development



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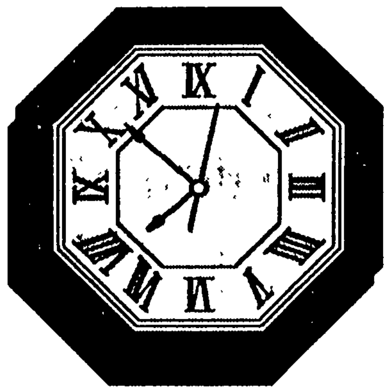
Training

- Training is mandatory for successful lPD/CE implementation
  - Before program start
  - During program execution
- Training is essential at several levels
  - Management
  - Team leaders
  - Team members
- Training is necessary in several areas, e.g.,
  - lPD/CE process
  - Team building
  - High performance team principles
  - Team based design
  - Quality function deployment (QFD)
  - Facilitation Skills

Training (Cont'd)



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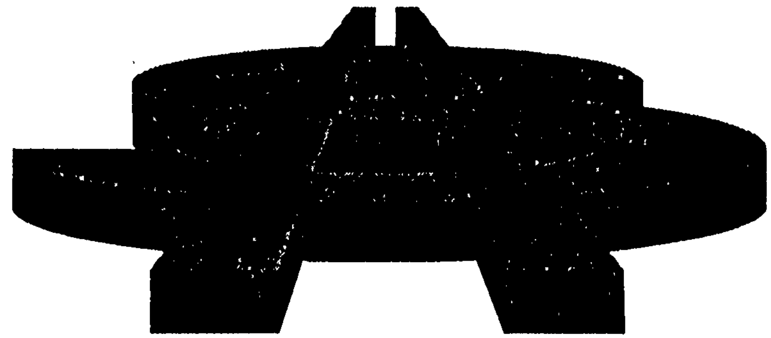

- Time and resource allocation often lacking because training needs are not properly prioritized
  - Proposal phase: Too busy doing the proposal
  - Pre-Contract: Spent all the money on the proposal
  - Post-Contract: Too Busy executing the contract

- Pay now. ..or pay later!

LOCKHEED MARTIN

TEAM LESSONS LEARNED

THE FOLLOWING LESSONS LEARNED ON TEAMS SHOULD BE USED WHEN DEVELOPING CE TEAMS IN A SHIPYARD:

- **CLEARLY DEFINE HOW TEAMS FIT INTO THE ORGANIZATION.**
- **TELL THE TEAM WHY CHANGE IN APPROACH IS BEING MADE.**
- **USE YOUR BEST PEOPLE ON THE EARLY TEAMS TO INCREASE PROBABILITY OF SUCCESS.**
- **MAKE SURE TEAM MEMBERS REALIZE THAT TEAM SUCCESS IS THEIR NUMBER 1 PRIORITY.**
- **GIVE THE TEAM ADEQUATE TRAINING IN** NECESSARY **SKILLS.**
- **SET BROAD OVERALL GOALS.**
- **MAKE SURE FUNCTIONAL MANAGERS ARE CARED FOR DURING THE DIFFICULT TRANSITION PERIOD.**

TEAM LESSONS LEARNED

(CONTINUED)

- GIVE THE TEAM TIME TO DEVELOP INTO A TEAM.
- ACCEPT THE FACT THAT ORIGINAL MEMBERS MAY NOT BE ABLE TO FORM A TEAM AND BE PREPARED TO REPLACE SOME MEMBERS QUICKLY.
- MAINTAIN TEAM MEMBERSHIP THROUGH THE DURATION OF THE PRODUCT DEVELOPMENT
- MEASURE TEAM PERFORMANCE NOT INDIVIDUAL PERFORMANCE.
- REWARD TEAM NOT INDIVIDUALS.
- TEAM PROBLEMS INCLUDE INEFFECTIVE TEAM MANAGEMENT, LACK OF TEAM SKILLS AND LACK OF TEAM EXPERIENCE. THESE CAN ALL BE REMEDIED BY EDUCATION AND TRAINING.
- IT IS MANDATORY THAT A SIGNIFICANT EDUCATIONAL PROGRAM BE UNDERTAKEN TO

TEAM LESSONS LEARNED

(CONTINUED)

- KEEP TEAMS FOCUSED ON MEETING CUSTOMERS (INTERNAL AND EXTERNAL) REQUIREMENTS.
- USE MUTUALLY AGREED METRICS TO MONITOR TEAM PERFORMANCE.
- USE A TRAINED FACILITATOR TO HELP TEAMS DEVELOP.
- HAVE TEAM DEVELOP CE PLAN FOR ACCEPTANCE BY THE TEAM SPONSOR PRIOR TO COMMENCING ACTUAL PRODUCT DEVELOPMENT.
- MANAGEMENT MUST UNDERSTAND CE APPROACH AND EMPOWER THE TEAMS.
- KEEP TEAMS RELATIVELY SMALL - 6 TO 12 MEMBERS.
- MAKE SURE THAT TEAM UNDERSTANDS THAT ALL MEMBERS MUST ACCEPT PRODUCT OWNERSHIP.

SEVEN SHADES OF GRAY

Instructios: Place a check mark on the scale indicating your belief about tthe strength/amount/goodness of each characteristic that should be found in an organization that supports empowered team.

Key: 7 is high; 1 is low

+ _7_ _6_ _5_ _4_ _3_ _2_ _1_ -

inconsistency	_ _ _ _ _ _ _	consistency
individuality	_ _ _ _ _ _ _	conformity
discontinuous change	_ _ _ _ _ _ _	incremental change
flexibility	_ _ _ _ _ _ _	rigidity
centers of power	_ _ _ _ _ _ _	chains of command
listening	_ _ _ _ _ _ _	telling
persuading	_ _ _ _ _ _ _	ordering
sharing information	_ _ _ _ _ _ _	protecting infomation
budget flexibility	_ _ _ _ _ _ _	budget rigidity
ambiguous assignments	_ _ _ _ _ _ _	single-focus assignments
shared recognition	_ _ _ _ _ _ _	individual recognition
informal	_ _ _ _ _ _ _	formal
avaliable	_ _ _ _ _ _ _	sequestered

Building High Performing Engineering Project Teams

Hans J. Thamhain

David L. Wilemon

Abstract. This article summarizes four year of research into the drivem and barriers of effective teambuilding in engineering work environments. A simple input-output model is presented for organizing and analyzing the various factors which influence team performance. The field survey results supported by conflation analysis indicate that team performance is primarily associated with six driving forces and six barriers which are related to: leadership, job content, personal needs,, and general work environment. Specific recommendations are made.

TEAM BUILDING DEFINED

Team buiding is the process of taking a collection of individuals with different needs, backgrounds, and expertise and transforming them into an integrated, effective work unit. In transformation process, the goals and energie individual contributors merge and support objectives of the team.

The basic concept of team building d back in history for a long time as summarize the listing of chronological development s below. However the onset of modem team bu

ing came with the evolution of multidisciplinary management techniques and contemporary organization forms such as the matrix. With these developments, traditional bureaucratic hierarchies declined and horizontally oriented teams and work units became increasingly important.

Today, team building is considered by many management practitioners and researchers to be one of the most critical leadership qualities that determines the performance and success of multidisciplinary efforts. The outcome of these projects critically depend on carefulIy orchestrated group efforts, requiring the coordination and integration of many task specialists in a dynamic work environment with complex organization interfaces. Therefore, it is not surprising to find a strong emphasis on teamwork and team building practice among today's managers, a trend which, wc expect, will continue and most likely intensify for years to come.

Some milestones in the evolution of team building and key contributors to the development of its concepts are shown below:

4000 BC	Egyptians	Demonstrated ability of formally organizing and controlling work groups.
• 1500 AD	Niccolo Machiavelli	Early explanation of work group structure and functioning. (The Prince).
• 1930's	Sloan, Mayo, Bernard.	Formal organization of work groups in bureaucratic, hierarchal structures. Autocratic behavior.
• 1950's	Simon, Lewin, Davis, Drucker	Understanding of group dynamics and behavior in organizations. Translation of established theories from individuals to work group settings.
• 1960's	McGregor, Likert, Carzo. Katz, Schein. Lawrence, Lorsch, Jewkes, Blake, Mouton, Fiedler	Increased managerial interest in team building and need for effective team work. Japanese lessons.
• 1970's	Bennington, Dyer, Kidder	Specific field studies of technical team work.
• 1980's	Ouchi, Thamhain, Wilemon.	Attempts to characterize drivers and barriers of high team performance. Theory development.

ENGINEERING TEAM BUILDING TODAY

Team building is important in any environment which requires the coordination and integration of multidisciplinary activities. It is especially crucial in a technical environment where projects arc often highly complex and require the integration of many functional specialties in an often unconventional organizational setting such as the matrix. To manage these multifunctional activities, it is necessary for the managers and their lead engineering personnel to cross organizational lines and deal with resource personnel over whom they have little or no formaI authority. Yet another set of challenges is presented by the contemporary nature of the engineering organization with its horizontal and vertical lines of communication and control, its resource sharings among projects and task teams, multiple reporting relationships to several bosses, and dual accountabtities.

Managing technical projects effectively in such dynamic environments requires the understanding of organizational and behavioral variables and their interaction. It is further necessary to foster a climate conducive to multidisciplinary

team building. Such a team must have a capacity for innovatively transforming a set of technical objectives and requirements into specific products, system concepts, or services that compete favorably against other available alternatives.

BASIS OF THIS REPORT

The team building concept is not entirely new, as shown in the text insert on evolution, but its application to systematic efforts within a permanent organizational framework-rather than temporary work setting-is relatively recent. Starting with the evolution of formal project organizations in the 1960's, managers in various organizational settings have expressed increasing concern and interest on the concepts and practices of multidisciplinary team building. Reponding to this interest, many field studies have been conducted investigating work group dynamics in a general context contributing to the heretical and practical understanding of team building.[2-4, 6, 13, 14, 18, 20, 38] However, few studies specifically focus on the process and criteria of building effectivc high-performing engineering teams.[18, 19, 24, 37] Because of this special need and interest the authors have organized and conucted a series of studies over the last four years. These field studies analyzed some 30 companies involving over 500 engineering professionals inuding 37 managers. All of these companies are U.S. based and were managers as high-technoogy businesses. The data were gathered prirarily by means of interviews augmented by short questionnaires. The results are documented five research papers listed below:

skill requirements for engineering program managers[30],
professional needs analysis of engineering personnel versus performance[29],
analysis of barriers to teamwork and potential effects on project performance[35],

4. determination of team performance measures and their drivers and barriers, some performance correlates[31],
5. a model for developing high-performing project teams.[37]

This article is an attempt to summarize and integrate the findings from our research and to establish a conceptional framework for effective team building in an engineering/tcehnological work environment.

Originally, a broadly stated proposition was defined to guide our research. It is restated here to focus this paper and to help in guiding the discussion:

> P: Engineering team performance is associated with drivers and barriers related predominately to 1) leadership and 2) a professionally stimulating work environment.

MODEL FOR TEAM BUILDING

The characteristics of a project team and its ultimate performance depends on many factors. Using a systems approach, Figure 1 provides a simple model for organizing and analyzing these factors. It defines three sets of variables 1) inputs such as resources and objectives, 2) outputs of the workgroups such as the team results or the team characteristics, and 3) influences toward effective team work such as leadership, job content, personal goals, and work environment. All of these variables are likely to be interrelated in a complex, intricate form. However, using the systems approach allows researchers and management practitioners to break down the complexity of the team work process which transforms resources into specific results under the influence of managerial, organizational, and other environmental factors. Furthermore, the model can provide a framework for studying

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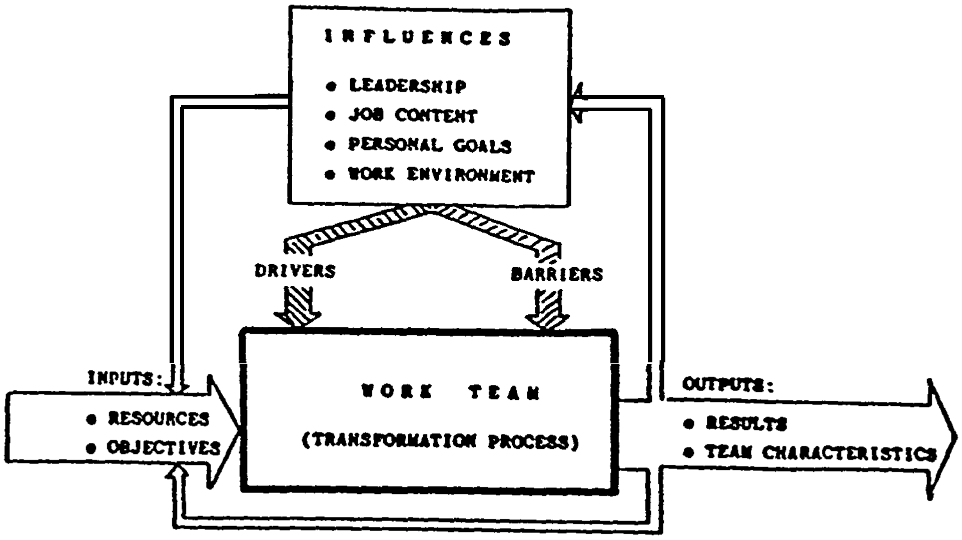

FIGURE 1. The Transformation of Resources and Objectives into Results Is Affected by a Variety of Drivers and Barriers

team characteristics and performance at various phases of a project life cycle. Such an investigation has been initiated by the authors. It will include the following project phases: 1) Project Definition and Planning, 2) Project Start-Up, 3) Main Phase, and 4) Project Phase-Out.

FACETS OF TEAM PERFORMANCE

Obviously, each organization has their own way to measure and express performance of a project team. However, in spite of the existing cultural and philosophical differences there seems to be a general agreement among engineering managers on certain factors which are included in the characteristics of a successful technical project team. In fact, over 90 percent of the 500 engineering professionals interviewed over the last four years mentioned three measures as the most important criteria for measuring team performance:

1. technical success,
2. on-time performance,
3. on-budget/within resource performance.

Further, over 60 percent of those who identified these three measures, ranked them in the above order.

When describing the characteristic of an effective, high-performing engineering team, managers point at the factors summarized in Figure 2. These managers stress consistently that a high-performing engineering team not only produces technical results on time and on budget but is also characterized by specific task- and people-related qualities as shown below.

Task-Related QuaIities

- oriented toward technical Sucess;
- Committed to the project result-oriented attitude:
- innovative and creative:
- concern for quality;
- willingness to change project plan if necessary;
- ability to predict trends;
- on-time performance;
- on-budget performance.

People-Related Qualities

- high involvement, work interest, and' energy;
- capacity to solve conflict;
- good communication;
- good team spirit;
- mutual trust;
- self-development of team members;
- effective organizational interfacing;
- high need for achievement.

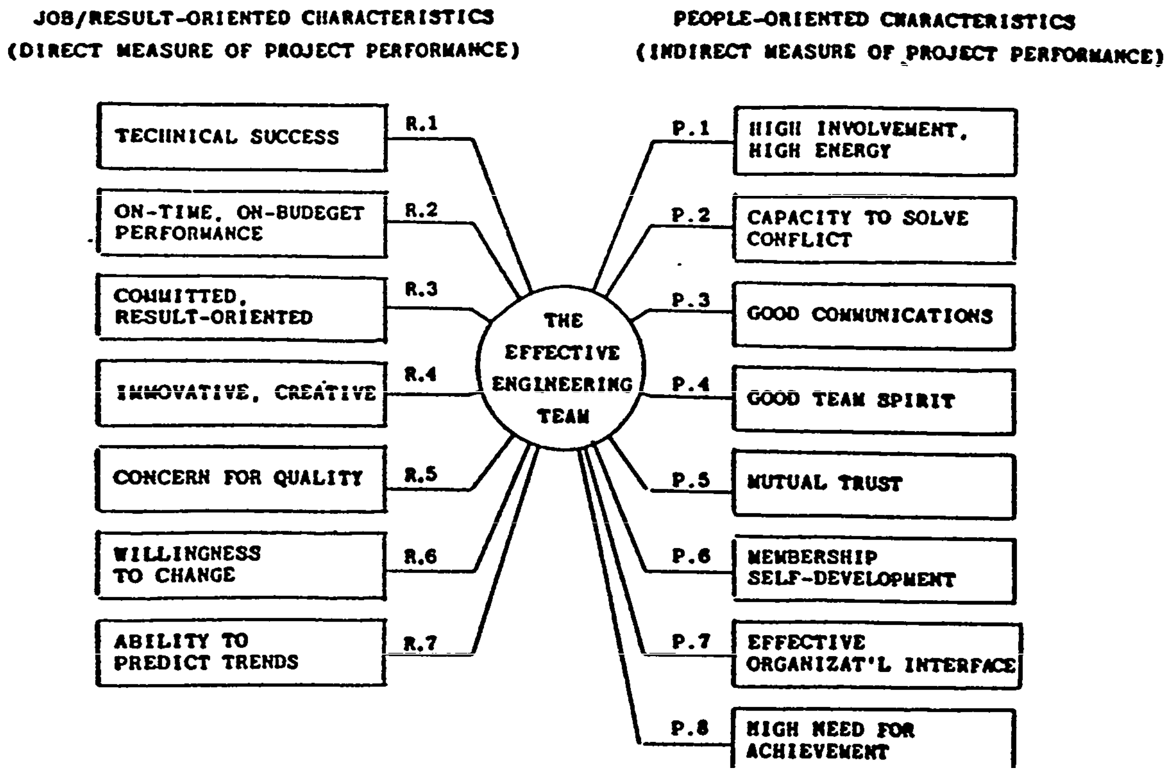

FIGURE 2. Characteristics of an Effective Engineering Team

In fact, some quantitative analysis, performed during previous studies[31, 32], shows a statistically significant association* between the above team qualities and team performance at a confidence level of p = 95 percent or better. Specifically, these measures yielded an average rank-order correlation of $\tau = 0.37$. Moreover, there appears to be a strong agreement between the two professional groups, 1) managers and 2) project team members, on the importance of these characteristics, as measured via a Kruskal-Wallis analysis of variance by ranks at a confidence level of p = 95 percent.

The significance of determining team performance characteristics is in two areas. First, it offers some clues as to what an effective team environment looks like. This can stimulate thoughts of how to foster a work environme responsive to the needs of the people and con(cive to team building. Second, the results al us to define measures and characteristics of effective team environment for further studi such as the subsequent discussion on drivers ε barriers toward team performance.

DRIVERS AND BARRIERS OF HIGH TEAM PERFORMANCE

In 1983 and 84, additional management insig was gained by an investigation of drivers a barriers to high team performance (see 31 a 35). Drivers are factors associated with the pr(ect environment that are perceived to be enhar ing team effectiveness, while barriers are pe ceived to be impeding team performance. listing of the principal drivers and barriers,

*For method and references to statistical modes see Appendix.

perceived by project professionals is shown below:

Drivers, Enhancing Project Performance	Barriers, Impeding Project Performance
• Professionally stimulating and challenging work;	• Different interests and priorities among team members;
• Professional growth potential;	• Unclear project objectives;
• Freedom to choose, decision making;	• Role conflict and power struggle among team members;
• Good overall direction and leadership;	• Excessive changes of project scope, spec, schedule and budget;
• Tangible rewards;	• Lack of team definition and structure
• Mutual trust, security, and open communications;	• Wrong capabtities, poor selection of project personnel;
• Proper experience and skills;	• Lacking commitment from team members or management
• Sense of accomplishment;	• Low credibilty of project leader;
• Good interpersonal relations among team members and with management	• Poor communications;
• Proper planning;	• Poor job security.
• Sufficient resources;	
• Low interpersonal conflict.	

Furthermore, studies conducted by Gemmill, Thamhain, and Wilemon between 1974 and 1985[29, 31-33] showed significant correlations and interdependencies among work-environmental factors and team performance. These studies indicate that high team performance involves four primary issues; 1) managerial leadership, 2) job content, 3) personal goals and objectives, and 4) work environment and organizational support.

In addition, a recent follow-up study by Thamhain (in part reported in[33]) used the above typology to collect data and categorize over 60 influence factors which were mentioned by engineering managers as drivers or barriers toward high team performance. The actual correlation of these influence factors to the project team characteristics and performance* provided some interesting insight into the strength and effect of these factors. One of the important findings was that only 12 of the 60 influence factors were found to be statistically significant.** All other factors seem to be much less important to high team performance. Specifically, the findings, summarized in Figure 3, indicate that the six drivem which have the strongest positive association with project team performance are

- Interesting and stimulating work,
- Recognition of accomplishment (of individual or team),
- Experienced engineering management personnel,
- Proper technical direction and leardership,
- Qualified project team personnel, and
- Professional growth potential

whale the strongest barriers to project team performance are:

- Unclear project objectives and directions,
- Insufficient resources,
- Power struggle and conflict,
- Uninvolved, disinterested senior management,
- Poor job security,
- Shifting goals and priorities.

It is furthermore interesting to note that the six drivers not only correlated favorably to the

*Kendall Tan rank-order correlation was used as a measure of association. For method and references to statistical models see Appendix.

**Statistical significance was defined at a confidence level of 95 percent or better.

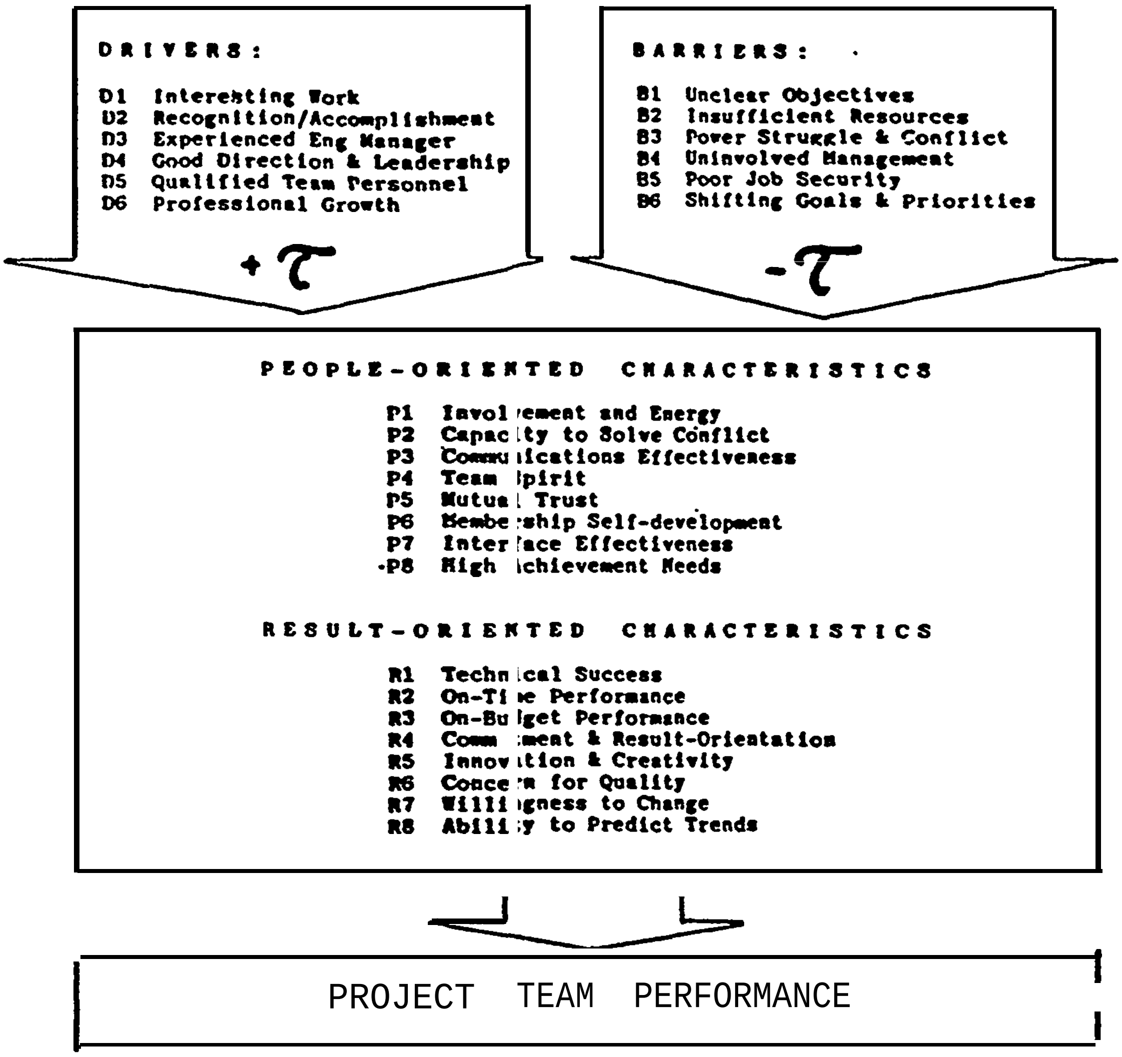

FIGURE 3. Major Drivers and Barriers toward Project Team Performance

direct measures of high project team performance, such as technical success andon-time/on-budget performance, but also were positively associated with the 13 indirect measures of team performance shown in Figure 2. The six barriers have exactly the opposite effect. These findings provide some quantitative support to previous exploratory field studies by the authors.[35, 37] What we find consistently is that successful organi.zations pay attention to the human side. They appear effective in fostering a work environment "conducive to innovative work, where people find the assignments challenging, leading to recognition and professional growth. Such a professionally stimulating environment also seems to lower communication barriers and conflict, and enhances the desire of personnel to succeed. This seems to enhance organizational awareness as well as the ability to respond to the often changing project rquirements.

In addition, a winning team appears to have good leadership. That is, management understands the factors crucial to success. They are action-oriented, provide the needed resources, properly direct the implementation of the project, plan, and help in the identification and resolution of problems in their early stages.

Taken together, the findings offer support

for the propositions P advances earlier and restated here somewhat modified and more specifically in two parts:

P1: The degree of project success seems primarily determined by the strength of six driving forces and six barriers which are related to: 1) leadership, 2) job content, 3) personal needs, and 4) the general work environment.

P2: A professionally stimulating team environment, characterized by 1) interesting challenging work, 2) visibility and recognition for achievements, 3) growth potential, and 4) good project leadership, is strongly correlated with project success. It also leads to low perceived conflict, high commitment, high involved personnel, good communicaions, change-orientation, innovation and on-time/on-budget performance.

Taken together, the findings show that to be effective in organizing and directing a project team, the leader must not only recognize the potential drivers and barriers but also know when in the life cycle of the project they are most likely to occur. The effective project leader takes preventive actions early in the project lifecycle and fosters a work environment that is conducive to team building as an ongoing process.

The effective team builder is usually a social architect who understands the interaction of organizational and behavioral variables and can foster a climate of active participation and minimal dysfunctional conflict.. This requires carefully developed skills in leadership, administration, organization, and technical expertise. It further requires the project leader's ability to involve top management to assure organizational visibility, resource availability, and overall support for the new project throughout its life cycle.

It is this organizational culture which adds yet another challenge to project team building. The new team members are usually selected from functional resource departments led by strong individuals who often foster internal competition rather than cooperation. In fact, even at the individual contributor level, many of the highly innovative and creative people are high individual. istically oriented and often admit their aversion to cooperation. The challenge to the proj manager is to integrate these individuals into a team that can produce innovative results in a systematic, coordinated, and integrated effort to accomplish the overall project plan. Many of the problems that occur during the formation of the new project team or during its lifecycle are normal and often predictable. However, they present barriers to effective team performance. They must be quickly identified and dealt with. The following section offers speceific suggestions.

RECOMMENDATIONS FOR ENGINEERING TEAM MANAGERS

A number of recommendations have been derived from the broader context of this study which can potentially increase the project manager's effectiveness in building high performing teams.

1. Barriers: Project managers must understand the various barriers to team development and build a work environment conducive to the team's motivational needs. Specifically, management should watch out for the following barriers: 1) unclear project objectives, 2) insufficient resources and unclear funding, 3) role conflict and power struggles, 4) uninvolved and unsupportive management, 5) poor job security, 6) shifting goals and priorities.

2. The Project Objectives and their importance to the organization needs to be clear to all personnel who get involved with the projeet. Senior management can help develop a "priority image" and communicate the basic project parameters and management guidelines.

3. Management Commitment: Project managers must continuously update and involve their managements to refuel their interest and commitment to the new project. Breaking the project into smaller phases and being able to produce short-range results frequently, can be important to this refueling process.

4. Image Building: Building a favorable image for the project, in terms of high priority, interesting work, importance to the organization, high visibility, and potential for professional rewards is crucial in attracting and holding high-quality people. It is also a pervasive process which fosters a climate of active participation at all levels; it helps to unify the new project team and minimizes dysfunctional conflict.

5. Leadership Positions should be carefully defined and staffed at the beginning of a new program. Key project personnel selection is the joint responsibility of the project manager and functional management. The crediblity of project leaders among team members, with senior management, and with the program sponsor is crucial to the leader's ability to manage the multi-disciplinary activities effectively across functional lines. One-on-one interviews are recomrnended for explaining the scope and project requirements, as well as the management philosophy, organizational structure, and rewards.

6. EFfective Planning early in the project life cycle will have a favorable impact on the work environment and team effectiveness. Since project managers have to integrate various tasks across many functional lines. Proper planning requires the participation of the entire project team, including support departments, subcontractors, and management. These comprehensive activities, which can be performed in a special project phase such as Requirements Analysis, Product Feasibility Assessment, or Product/ Project Definition, usually have a number of team building benefits.

7. Involvement: One of the side benefits of proper project planning is the involvement of personnel at all organizational levels. Project managers should drive such an involvement, least with their key personnel, especially duri the project definition phases. This involveme will lead to a better understanding of the task r quirements, stimulate interest, help unify t team, and ultimately lead to commitment to t project plan regarding technical performanc timing, and budgets.

8. Project Staffing: All project assignmer should be negotiated individually with each pr spective team member. Each task leader shou be responsible for staffing his or her own ta team. Where dual-reporting relationships are i volved, staffing should be conducted jointly the two managers. The assignment intervi should include a clear discussion of the specif task, the outcome, timing, responsibilities, r porting relation, potential rewards, and impo tance of the project to the company. Task assig ments should be made only if the candidate ability is a reasonable match to the position r quirements and the candidate shows a healt degree of interest in the project.

9. Team Structurc Management needs to d fine the basic team structure and operating co cepts early during the project formation phas The project plan, task matrix, project charte and policy are the principal tools. It is the r sponsibility of the project manager to commun cate the organizational design and to assure th all parties understand the overall and interdisc plinary project objectives. Clear and freque communication with senior management and tl new project sponsor becomes critically impo tant. Status review meetings can be used for fee back.

10. Team Building Sessions should be co ducted by the project manager throughout tl project lifecycle. An especially intense effor might be needed during the team formatic stage. The team is being brought together in relaxed atmosphere to discuss such questions as

- How are we operating as a team? What i our strength? Where can we improve? Wha

steps are needed to initiate the desired change?

- What problems and issues are we likely to face in the future? Which of these can be avoided by taking appropriate action now? How can we "danger-proof" the team?

II. Team Commitment: Project managers should determine lack of team member commitment early in the life of the project and attempt to change possible negative views toward the project. Since insecurity is often a major reason for lacking commitment, managers should try to determine why insecurity exists, then work on reducing the team members' fears. Conflict with other team members may be another reason for lack of commitment. It is important for the project leader to intervene and mediate the conflict quickly. Finally, if a team member's professional interests may lie elsewhere, the project leader should examine ways to satisfy part of the team member's interests by bringing personal and project goals into perspective.

12. Senior Management Support: It is critically important for senior management to provide the proper environment for the project team to function effectively. Here the project leader needs to tell management at the onset of the program what resources are needed. The project manager's relationship with senior management and ability to develop senior management support is critically affected by his or her-credibtity, visibility, and priority image of the project.

13. Organization Development Specialists: Project leaders should watch for changes in performance on an ongoing basis. If performance problems are observed, they should be dealt with quickly. If the project manager has access to internal or external organization development specialists, they can help diagnose team problems and assist the team in dealing with the identified problems. These specialists can also bring fresh ideas and perspectives to difficult, and sometimes emotionally complex situations.

14. Problem Avoidance: Project leaders should focus their efforts on problem avoidance, That is, the project leader, through experience, should recognize potential problems and conflicts at their onset and deal with them before they become big and their resolutions consume a large amount of time and effort.

A FINAL NOTE

In summary, effective team building can be a critical determinant of project success. Building the engineering team for a new technical project is one of the prime responsibilities of the program leader. Team building involves a whole spectrum of management skills to identify, commit, and integrate the various personnel from different functional orgatitions into a single task group. In many project-oriented engineering organizations, team building is a shared responsibtity between the functional engineering managers and the project manager, who often reports to a different organization with a different superior.

To be effective, the project manager must provide an atmosphere conducive to teamwork. Four major considerations are involved in the in tegration of people from many disciplines into an effective team: 1) creating a professionally stimulating work environment, 2) good program leadership, 3) providing qualified personnel, and 4) providing a technnically and organizationally stable environment. The project leader must foster an environment where the new product team members are professionally satisfied, involved, and have mutual trust. The more effectively project leaders develop team membership, the higher is the quality of information exchanged, including the candor of sharing ideas and approaches. It is this professionally stimulating involvement that also has a pervasive effect on the

team's ability to cope with change and conflict, and leads to innovative performance. By contrast, when a member does not feel part of the team and does not trust others, information will not be shared willingly or openly. One project leader emphasized this point: "There's nothing worse than being on a team when no one trusts anyone else. . . . Such situations lead to gamesmanship and a lot of watching what you say because you don't want your own words to bounce back in your face. . . ."

Furthermore, the greater the team spirit, trust, and quality of information exchange among team members, the more likely the team will be able to develop effective decision-making processes, make individual and group commitment focus on problem solving, and develop self-forcing self-correcting project controls. These are the characteristics of an effective and productive project team.

Over the next decade we anticipate important developments in team building which will lead to higher performance levels, increased morale, and a pervasive commitment to final results. Areas which should be further investigated include 1) applicability of our findings to ergineering teamwork in general, 2) the differences and similarities to nonengineering teams, 3) additional studies into team performance and their correlates, and 4) studies of team performance at various project life cycle stages. These are just a few of the areas that deserve future study, and we hope that this paper will stimulate additional thoughts and research activity.

This paper summarizes several important aspects of team building in an engineering environment. It should help both the professional in the field of engineering management as well as the scholar who studies contemporary organizational concepts to understand the intricate relationships between organizational and behavioral elements. It also provides a conceptional framework for specific research and situational analysis of engineering teambuilding practices.

APPENDIX: STATISTICAL MEASURES AND RANK-ORDER CORRELATION

Association between Team Characteristics and Team Performance

The association was measured by utilizing I dall's Tau Rank-Order Correlation and Part Rank-Order Correlation. First, projects v rank-ordered by managers according to their formance. Then the various factors descril the team characteristics were each rank-ord by both managers and team members accor to their strength. Finally, the Tau Coeffici and their significance were calculated for association. For mathematically procedure see

The Kruskal-Wallis One-Way Analysis of Variance by Ranks

The Kruskal-Wallis analysis is a test for deci whether K independent samples are from dif ent populations. In our study the test verifies both managers and other project team memb believe in essentially the same qualities t shouId be present within an effective, high p forming project team.

Correlation of Drivers and Barriers to Team Performance

Project team members were asked to rate e of the influence factors, shown as Drivers Barriers in Figure 3. The rating measured presence of each of these factors in the team vironment, using a five-point scale ranging f "strongly agree" to "strongly disagree." team rankings based on these scores were t correlated against the team rankings based Performance (P and R scores) as perceived senior managers (R-scores) and project manag (P-scores). While the correlation factors in Ta 1 are based on the perception of managers team members as indicated respectively, all f tors were measured as a perception of both,

TABLE 1. Drivers and Barriers toward Technical Team Performance

	People-Oriented Characteristics								Result-Oriented Characteristics								Avge
	P1	P2	P3	P4	P5	P6	P7	P8	R1	R2	R3	R4	R5	R6	R7	R8	PR
Drivers (+ τ):																	
D1 Interesting Work	+.45	.55	.35	.40	.30	.10	.20	.55	.30	.30	.20	.50	.25	.25	.25	.10	.32
D2 Recognition/ Accomplishment	+.40	.35	.20	.25	.30	.30	.15	.60	.25	.25	.15	.35	.15	.40	.10	.15	.27
D3 Experienced Eng Manager	+.20	.10	.25	.20	.20	.25	.30	.25	.35	.30	.30	.30	.25	.30	.30	.35	.26
D4 Proper Direction & Leadership	+.10	.12	.35	.20	.05	.10	.20	.30	.55	.35	.30	.30	.25	.30	.25	.30	.25
D5 Qualified Team Personnel	+.12	.20	.30	.25	.10	.30	.20	.25	.25	.35	.30	.10	.35	.45	.10	.30	.24
D6 Professional Growth Potential	+.15	.10	.10	.15	.10	.10	.05	.25	.10	.15	.10	.25	.10	.30	.10	.20	.14
BARRIERS (−τ):																	
B1 Unclear Objectives	−.45	.45	.20	.35	.40	.20	.35	.15	−.40	.20	.20	.55	.25	.15	.30	.35	.31
B2 Insufficient Resources	−.30	.35	.05	.35	.25	.05	.10	.20	−.35	.40	.55	.40	.00	.35	.10	.35	.26
B3 Power Struggle & Conflict	−.25	.60	.10	.40	.45	.30	.25	.15	−.20	.15	.20	.35	.20	.30	.20	.10	.26
B4 Uninvolved Management	−.35	.25	.25	.45	.30	.05	.10	.05	−.35	.10	.15	.35	.20	.30	.15	.35	.23
B5 Poor Job Security	−.10	.30	.20	.40	.40	.10	.15	.10	−.30	.20	.15	.35	.15	.35	.20	.30	.23
B6 Shifting Goals & Priorities	−.30	.25	.15	.20	.15	.05	.25	.15	−.20	.35	.35	.15	.15	.40	.25	.10	.22

Significance Levels:
$\tau \geq .25 \ldots p \leq .05$
$\tau \geq .35 \ldots p \leq .01$

P1: Involvement and Energy
P2: Capacity to Solve Conflict
P3: Communications Effectiveness
P4: Team Spirit
P5: Mutual Trust
P6: Membership Self-development
P7: Interface Effectiveness
P8: High Achievement Needs

R1: Technical Success
R2: On-Time Performance
R3: On-Budget Performance
R4: Commitment & Result Orientation
R5: Innovation & Creatively
R6: Concern for Quality
R7: Willingness to Change
R8: Ability to Predict Trends

Kandell Tau Correlation of Team Characteristics and Team Performance

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fact showing a reasonably high statistical concurrence. Finally, those influences which correlated predominately positive were characterized as drivers, those that correlated predominately negatively were characterized as barriers. The labeling of the variables in Table 1 is according to Figure 3, the statistical significance is indicated as follows: $\tau \geqq 0.25$ indicates a 95-percent confidence level ($p \leq 0.05$), and $\tau \geqq 0.35$ indicates a 99-percent confidence level ($p \leq 0.01$).

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IMPLEMENTING ADVANCED TECHNOLOGY STRATEGY DEVELOPMENT

320

WHERE ARE WE?

AS INDIVIDUAL SHIPYARD

1 2 3 4 5

AS AN INDUSTRY

1 2 3 4 5

WHAT ARE CRITICAL SUCCESS FACTORS?

WHAT SHOULD BE DONE NEXT?

INDIVIDUAL SHIPYARDS

WHAT SHOULD BE DONE NEXT?

SHIPBUILDING INDUSTRY

WHAT SHOULD BE DONE NEXT?

NATIONAL SHIPBUILDING RESEARCH PROGRAM

ATTENDEE FORMS

DAILY LOG

COURSE EVALUATION

PERSONAL ACTION PLAN

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DAILY LOG

The purpose of this daily log is for you to pick out and record the most personally significant experience of the day and what you learned from it.

This will involve reflecting on:

- what experience during the day was most significant to you personally
- why this was personally significant
- what you learned from it
- any actions you propose to take as a result

Of course, you need not restrict your record to only one experience.

You can also use the daily log to record your thoughts, ideas, insights and feelings. This may include reflections on what worked and what did not work (and why) and ideas for possible improvements. It may include reflections on the relevance of the course experiences to activities and experiences outside of the course.

DAILY LOG

DAY 1

WHAT WAS THE MOST PERSONALLY SIGNIFICANT EXPERIENCE?

WHY WAS THIS PERSONALLY SIGNIFICANT?

WHAT DID YOU LEARN?

WHAT ACTIONS WILL YOU TAKE OR PROPOSE AS A RESULT?

ALSO RECORD ANY OTHER THOUGHT, IDEAS, INSIGHT AND FEELING

DAILY LOG

DAY 2

WHAT WAS THE MOST PERSONALLY SIGNIFICANT EXPERIENCE?

WHY WAS THIS PERSONALLY SIGNIFICANT?

WHAT DID YOU LEARN?

WHAT ACTIONS WILL YOU TAKE OR PROPOSE AS A RESULT?

ALSO RECORD ANY OTHER THOUGHT, IDEAS, INSIGHT AND FEELING

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COURSE EVALUATION

We would be very grateful for your feedback on the course. Please complete this evaluation form and return it at the end of the course. Two copies are provided so that you can keep a copy of your evaluation. Thank you!

THE MOST HELPFUL THINGS I LEARNED FROM THE COURSE ARE:

1.

2.

3.

WHAT I LIKED BEST ABOUT THE COURSE WAS:

WHAT I DISLIKED MOST ABOUT THE COURSE WAS:

RECOMMENDATIONS FOR FUTURE COURSES

ANY OTHER COMMENTS?

NAME (OPTIONAL)

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NSRP SP-9 PANEL SHORT COURSE ON IMPLEMENTING ADVANCED TECHNOLOGY

COURSE EVALUATION

We would be very grateful for your feedback on the course. Please complete this evaluation form and return it at the end of the course. Two copies are provided so that you can keep a copy of your evaluation. Thank you!

THE MOST HELPFUL THINGS I LEARNED FROM THE COURSE ARE:

1.

2.

3.

WHAT I LIKED BEST ABOUT THE COURSE WAS:

WHAT I DISLIKED MOST ABOUT THE COURSE WAS:

RECOMMENDATIONS FOR FUTURE COURSES

ANY OTHER COMMENTS?

NAME (OPTIONAL)

PERSONAL ACTION PLAN

In the light of your thinking and activities during this course, what are now your principal related targets or goals? Write the top three in order of priority:

1.

2.

3.

What actions will be necessary for you to achieve these targets or goals?

Your actions　　　　Other people's action

1.

2.

3.

For each of your three targets or goals, write below something that would be visible evidence that you had achieved them:

1.

2.

3.

Enter the dates that you plan to complete each of your targets or goals:

1.
2.
3.

NAME:　　　　**DATE:**

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